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McGRAW-HILL WEEKLY FOR DESIGN ENGINEERS · JULY 10, 1961

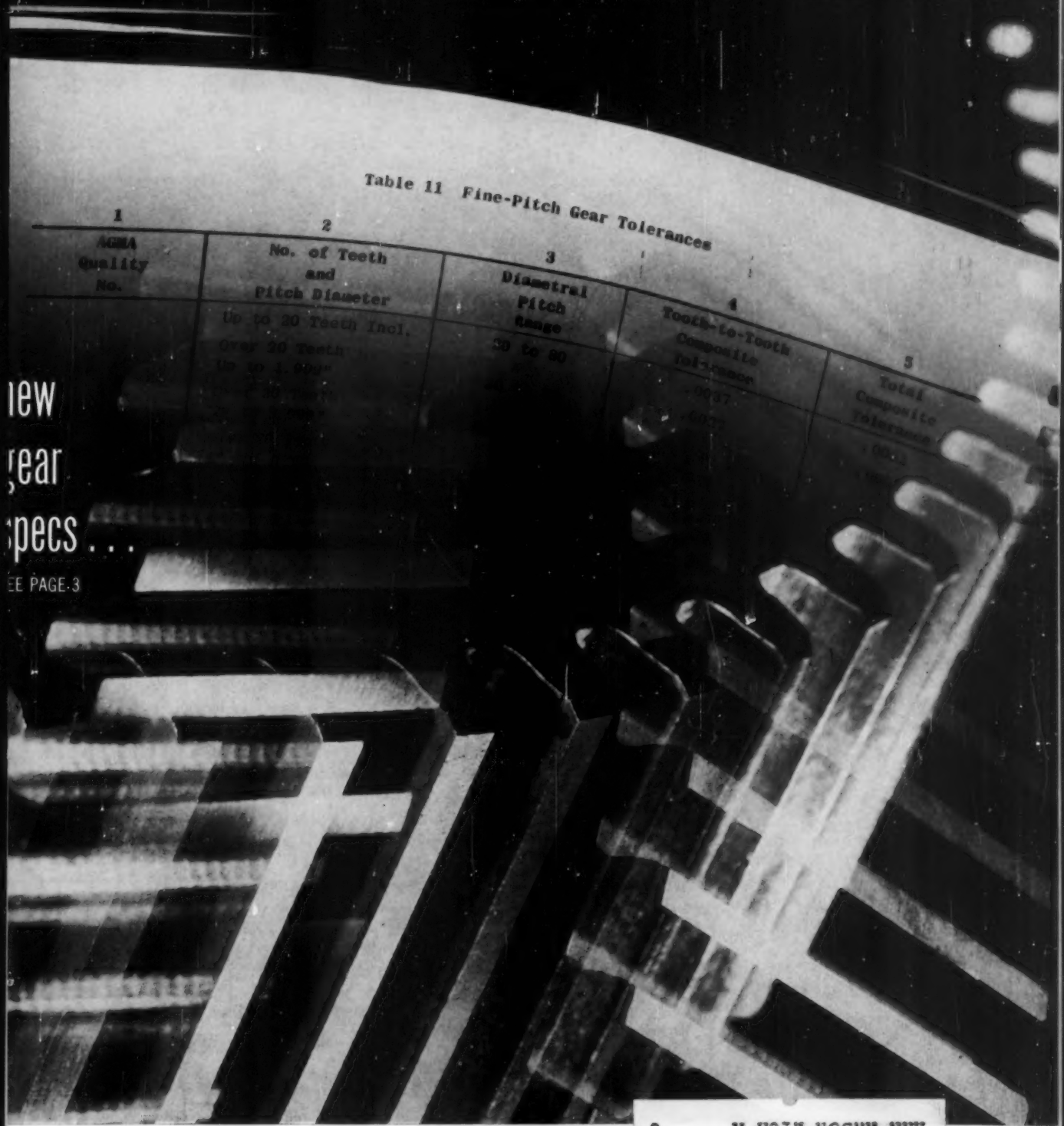

Table 11 Fine-Pitch Gear Tolerances

1 AGMA Quality No.	2 No. of Teeth and Pitch Diameter	3 Diametral Pitch Range	4 Tooth-to-Tooth Composite Tolerance	5 Total Composite Tolerance
	Up to 20 Teeth Incl.	20 to 80	.0007	.0012
	Over 20 Teeth Up to 1.000"		.0007	.0012

new gear specs . . .

SEE PAGE 3

UNCONVENTIONAL POWER SOURCES . . . page 57
7 STEPS TO CLEANER FLUID SYSTEMS . . . page 60
WHAT GOES INTO RUBBER? . . . page 62

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UP TO 5hp... NEW WORTHINGTON MONOBLOC X-COMPRESSOR

Based on purchase price, on extremely long compressor life . . . and on safety, too . . . your best buy for a 1½- to 5-h.p. air supply is the new Worthington MONOBLOC X-Compressor.

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PRODUCT ENGINEERING

McGRAW-HILL WEEKLY FOR DESIGN ENGINEERS

July 10, 1961 Vol. 32, No. 28

FEATURED:

DEPARTMENTS:

INTERESTING TO NOTE 3
WHAT'S NEW IN RESEARCH 6
DEVELOPMENTS TO WATCH 8
FROM WASHINGTON 12
THE ENGINEERING WEEK 15
POINTS OF VIEW 24
READER TO EDITOR 28
MEETINGS 29
WHY NOT R&D 32
HORIZONS 55
PRODUCT DESIGN 65
DESIGN FILE 79
SIGNIFICANT COMPONENTS 82
DESIGN LITERATURE 97
REPRINTS 107
ADVERTISERS INDEX 108
READER SERVICE CARDS 109

UNCONVENTIONAL POWER SOURCES . . . C J Lynch
8 laboratory curiosities promise power for the future 57

7 STEPS TO CLEANER FLUID SYSTEMS . . . G Wenner
How to anticipate contamination problems before they occur 60

WHAT GOES INTO RUBBER? . . . G McKenzie
Identifying the main ingredients and what they do 62

NEW AGMA GEAR CLASSIFICATIONS . . . N P Chironis
Widened quality range and new material classes 68

MORE FUNCTIONS FOR A SINGLE PART . . . P S Amber
Multiplexing gives less expensive, more-efficient designs 75

TORQUE-LIMITERS PROTECT LIGHT-DUTY DRIVES . . . L Kasper
8 devices disconnect drives during torque surges 79

FIELDS OF INTEREST REPRESENTED IN DEPARTMENTS:

MATERIALS:
New alloys for magnetic cooling 6
Glass solders and ceramic cements aid design 9

MECHANICAL:
Adhesive failure gets four definitions 6
Low-cost pressure gage does multiple jobs 6
Why parts fail—more data available 8
Linear actuator controls to 1 part in 1000 82

ELECTRICAL:
Circuit board is electric insulator and thermal conductor 8
High-rate ignition system designed in Britain 9
Electrical laminates improved with new papers 9

PRODUCT DESIGNS:
Gear errors pinpointed in graphic plot 65
Cams cure curves in welding 66

GENERAL:
Sunlight's "push" calculated 6
US patent policy may follow Dutch proposal 12
Progress in business machines reported from Japan 15
Next ship for Mohole will be more automatic 20

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GASKET GAUGE vs. TORQUE RETENTION

Gasket thickness is one of several factors affecting retention of initial torque loads. New study indicates significance of minor variations in gauge.

E. M. SMOLEY
Research Physicist
Armstrong Research and Development Center

Significant variations in the torque retention of a gasket material result from relatively small changes in thickness. This is one of the conclusions of a general study of the torque-retention problem made at the Armstrong Research and Development Center.

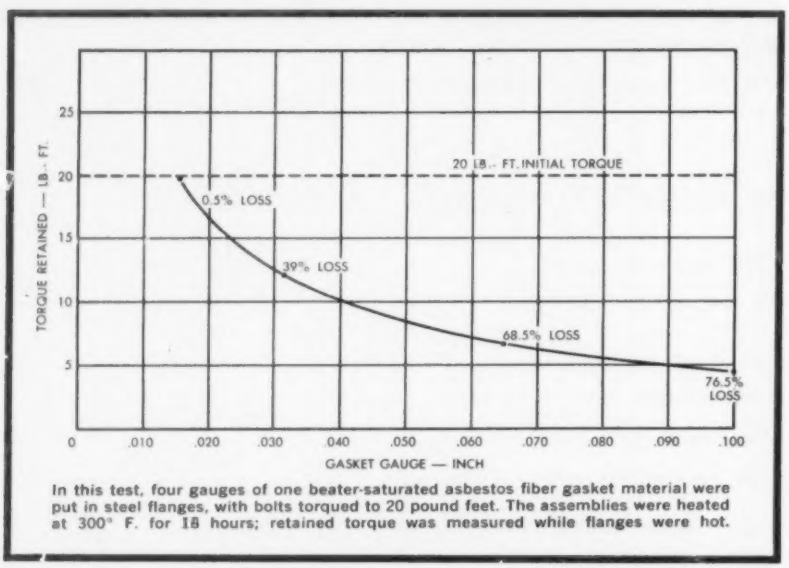
Generally, this work confirmed the widely accepted idea that maximum torque retention is usually obtained by using the thinnest gasket possible. But the magnitude of variation produced by changes in gauge was greater than had previously been estimated.

One phase of the study is charted above. In this curve, retained torque is plotted along the vertical scale, and uncompressed gasket thickness is indicated along the horizontal scale. The initial bolt torque was 20 pound feet for each of the gauges tested.

In the test, each different gauge of the material was bolted between steel flanges, and the assemblies were placed in an oven at 300° F. for 18 hours.

Torque was then re-measured while the flanges were still hot. The thinnest gasket (1/64″) showed an exceptionally low torque loss of only ½ of 1%.

The torque loss rose to 39% for the 1/32″ gauge. The loss for the 1/16″ material was 68.5%.



In this test, four gauges of one beater-saturated asbestos fiber gasket material were put in steel flanges, with bolts torqued to 20 pound feet. The assemblies were heated at 300° F. for 18 hours; retained torque was measured while flanges were hot.

It is estimated that bolts at least 5″ long would be required to eliminate most of the torque loss (76.5%) on the 1/10″ material. Actually, 1″ bolts were used in all these determinations.

In addition to these mechanical advantages, the use of thin gaskets also lowers cost and minimizes extrusion problems.

However, Armstrong engineers point out that there are mechanical factors that limit gauge reduction beyond a certain point. One is that, to provide a seal, gaskets must be compressed more than the cumulative deviation from perfect parallelism of the two flange surfaces.

For example, take a 1/32″ gasket cut from a material capable of a 50% compression. If used where the cumulative inaccuracies of the flanges are more than 1/64″, leaks will result. The alternatives are to use a thicker gasket, or a more compressible material.

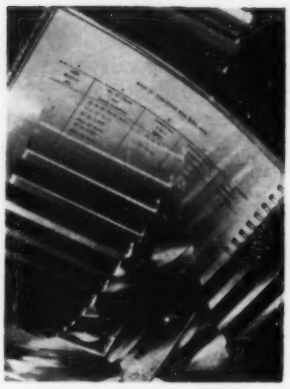
Sheet metal or other lightweight flanges that permit bowing between bolts also work against the use of thin gauge gaskets. The bowing can sometimes be compensated by using a thicker gasket or a more compressible material. A more desirable alternative is to build more rigidity into the flange.

Gasket thickness is only one of many factors in gasket engineering that are under continuous study at the Armstrong Research and Development Center.

In the course of this work, we have built up a large library of data on gasket engineering. If you have a problem involving gasket design, selection, or performance, we may already have the answer. We will be glad to make suggestions if you will submit details to us. Write to Armstrong Cork Company, Industrial Division, 7107 Irvin Street, Lancaster, Pa.

Armstrong GASKET MATERIALS

INTERESTING TO NOTE



On our cover—Gears supplied by Farrel-Birmingham Co, Ansonia, Conn, and photographed by Hans Baskin in McGraw-Hill's photo studio. As the article on page 68 points out, the new AGMA classification system for gears widens quality range, classifies materials and set up 16 new quality classes. The development of a set of standards is often a complicated time-consuming matter. In 1870, for example, it was decided to hold an international conference on standards. It took five years before representatives of 19 nations assembled in Paris signed an agreement which provided for the establishment and maintenance of a permanent International Bureau of Weights and Measures. In the 1870's came an interesting development from an entirely different direction—the air.

Charles Renard was known in France chiefly as a hero of the sky, into which he had ventured several times on experimental balloon ascensions. As a balloonist and secretary of a French "commission on aerial communications," Col Renard faced a comparatively new set of problems in devising specifications for equipment required for military balloons. He found, for instance, that the French Army had adopted no fewer than 425 different sizes of cordage for mooring balloons.

In trying to determine the best diameters for the cordage, Renard hit upon a new principle. The different sizes, he felt, should increase from size to size in a geometric ratio based on a progression of weights per meter of cordage. Renard used this principle of geometric progression for reducing cordage to 17 standard sizes, and for standardizing toggles, eyelets, and pulleys. He then extended his principle to develop a series of "preferred numbers," still known in France as the "Renard series."

A hard bird to follow

Nearly 50 years ago, Charles Sumner Bird, Progressive Party candidate for governor of Massachusetts, decided to speak at every post office in the state during his 6 weeks' campaign for the office. Such a decision would probably cause little stir today, but in 1913 it was quite an ordeal. Roads were in terrible condition, and tires had to be constantly repaired—the ingredients of rubber in those days were nothing like the kind we have today as the article on page 62 points out.

Bird's "flying squadron" consisted of four Stevens-Duryea automobiles. If one broke down, the candidate continued his journey in another. Though his squadron was forced to weather such trails as "the worst road in New England, that from Blandford to West Granville and Tolland, where the highway is little more than a path strewn with boulders," and plow through "two ruts full of

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gummy mud, called the road from New Marlboro to Sandisfield," Bird proved the possibility of physically presenting himself to the voters in all parts of the state. He waged a vigorous campaign among the thrifty New Englanders, under such slogans as "Bird for Governor means a man at the head of the old Bay State who thinks more of Men than Money, but who knows how to give you a dollar's worth of government for every dollar paid in taxes."

It was the first time an auto played a major role in a political campaign. But to no avail—Bird lost the election.

Black—but a bright future

Although carbon was one of man's first harnessed elements, it wasn't identified until an unknown Greek chemist of long ago labeled it *adamas*, meaning "invincible." Its earliest use was probably as a "drawing stick." Cavemen would use charred wood as implement with which to sketch their accomplishments on cave walls. Later, Chinese and Egyptian civilizations turned to carbon for painting their palaces and temples. This was a form of carbon black, or perhaps graphite. Graphite itself was known in early times and used extensively during the Middle Ages, but not until the latter part of the 18th century were its true chemical properties recognized and identified by Karl W Scheele. The Swedish chemist demonstrated its carbon content by igniting it in a current of oxygen. Then in 1789, the minerologist Abraham Werner named the substance "graphite."

Scheele, in his experiments with graphite and other forms of the organic element, found that it had the property of being able to remove coloring from certain chemical solutions. Then, in 1777, he reported that wood charcoal would adsorb certain gases. Several decades later it was found that another form of carbon, bonechar, was more effective for decolorization. From this crude beginning began the study of organic chemistry. Today the known number of organic compounds is better than one million and the number is increasing rapidly each year. Perhaps the most common source of carbon today is coal, one of our most versatile raw materials. Not only is it a valuable power source (p 57) in its own right; coal has also been transformed in the laboratory into an ever growing variety of products—nylon, plastics, sulfa drugs, dyes, vitamins, to name but a few. Although the coming of oil, gas and atomics has given us more types of energy to serve our needs, there are estimates that by 1975 we will be using twice as much coal as we do today.

—Benedict A Leerburger Jr

SIDELIGHT

A recent issue of *The Financial Post* reported, "Some English management consultant has found that distinctive company ties improve the esprit de corp of British workers. Not only has the company tie idea caught on widely, but some UK companies are using different colored ties (all with the same company crest) to indicate the length of the employe's service." We wonder how some of our nonconformist engineer friends would react if this English custom crosses the Atlantic. As *The Financial Post* suggests, "Whoever invented this scheme should be strangled in his own school tie."

NEXT WEEK IN PRODUCT ENGINEERING

. . . Functional finishes for metals

This special report provides a fresh look at organic finishes, electroplated metals, hot dipped coatings, bonded-in-place lubricants and others.

. . . Is your invention patentable—and worth it?

Don't wait until your new product is ready to market and then start a last-minute scramble for a patent.

. . . Mechanical timers

Continuous improvements in material and design make them a good choice for triggering one or two sequential operations.

. . . Designing flat springs—width and thickness

Simplifying factors fit 8 types of single and laminated flat springs in same nomograph.

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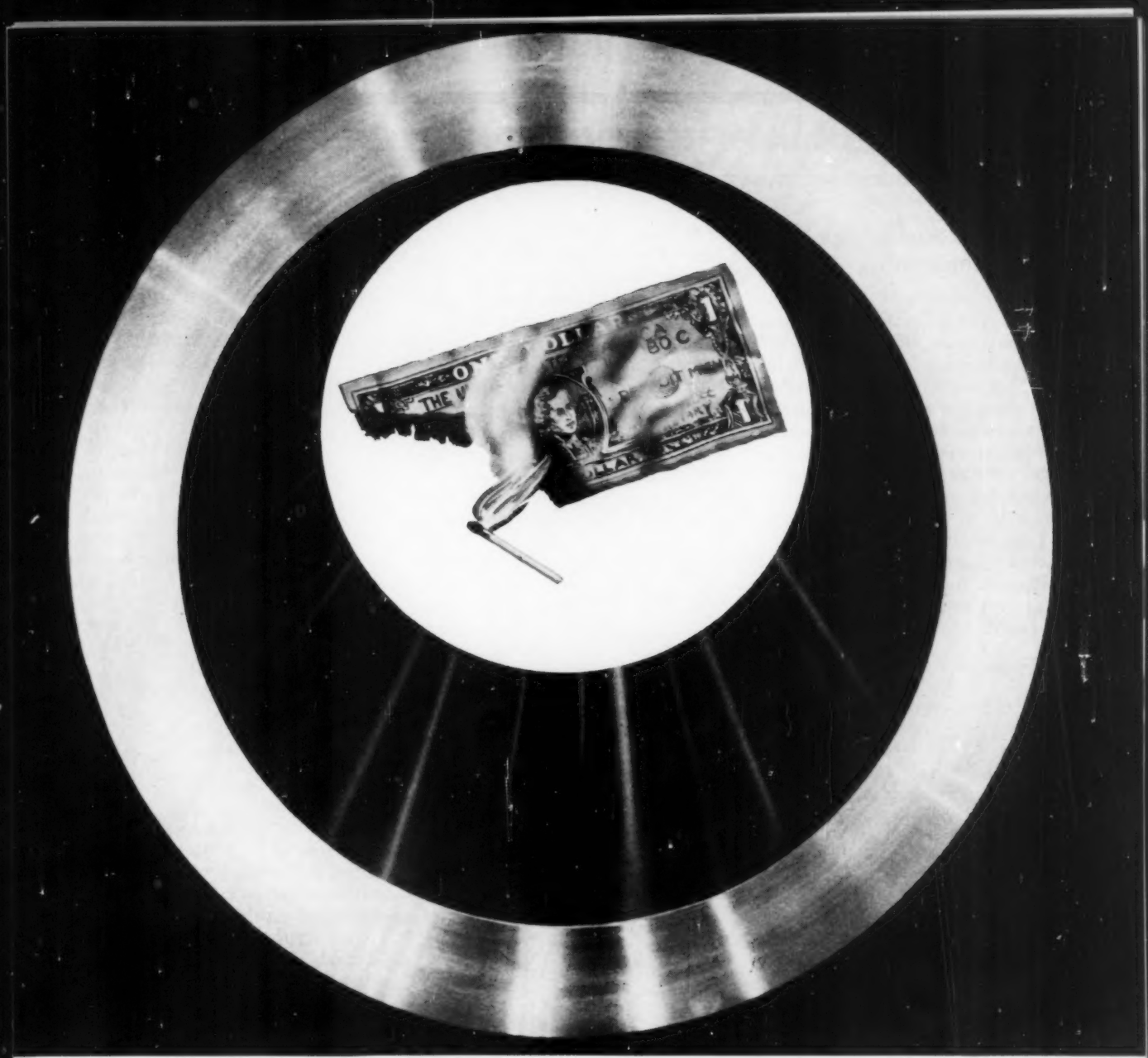

WHY PAY FOR METAL WASTE?

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*Patent applied for

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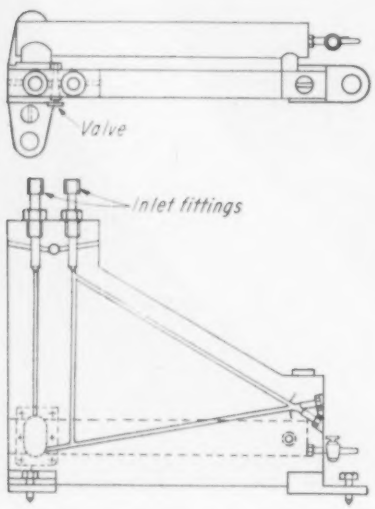
WHAT'S HAPPENING IN RESEARCH . . .

Low-cost pressure gage does multiple jobs

Using a transparent acrylic plastic for all parts, the Czechs have designed the combination differential manometer-micromanometer diagramed below. They say it's lightweight, portable, costs about ½ as much as conventional units, and can be used as a differential manometer, micromanometer, or drift gage. It will stand temperatures to about 120 F and pressures to about 70 psi.

Engineers at the Czech Oil Engine Factory (Prague) designed it, and a description (by Jiri Horka) appeared in a recent issue of the *Czech Technical Digest*.



PRESSURE GAGE is longitudinally bored plastic block with two vertical and two inclined capillaries, and large cylinder filled with measuring liquid (water or mercury). Provision of dual tube system makes unit self-checking. Bolts in base are used for leveling.

New alloys for magnetic cooling

Rare-earth alloys with "unique low temperature properties" and potential applications in magnetic cooling are reported by R. D. Parks and W. A. Little of Stanford U in a letter to the *Physical Review*.

These are thorium-erbium compositions, (1 to 10% Er), and seem superior in several respects to other rare-earth alloys and to the paramagnetic salts. The new alloys show magnetic ordering only at temperatures very close to absolute zero (below 1 K), and have good thermal properties.

Using the new alloys for magnetic cooling, Parks and Little have already been able to reach temperatures as low as 0.2 K in a cyclic magnetic refrigerator and they believe temperatures of 0.1 K and below, with high heat extraction rates, can be achieved.

Binary alloys of other "new" and unusual metals are also showing promise for cryogenic research. R. D. Blaugher of Martin and J. K. Hulm and A. Taylor of Westinghouse have been testing such combinations as tungsten-osmium, tungsten-rhenium, rhenium-hafnium, hafnium-molybdenum and molybdenum-hafnium at temperatures down to 1 K, and say their cryogenic properties are distinct enough so they can be used as a metallurgical "tool" in determining crystallinity and deviations from apparent stoichiometric composition.

Four definitions for adhesive failure

To its standard definitions of terms relating to adhesives, ASTM is proposing to add four new ones that define areas of failure:

Failure, **Adhesive**–Rupture of an adhesive bond, such that the plane of separation appears to be at the adhesive-adherend interface.

Failure, **Cohesive**–Rupture of an adhesive bond, such that the separation appears to be within the adhesive.

Failure, **Adherend**–Rupture of an adhesive bond, such that the separation appears to be within the adherend.

Failure, **Contact**–Failure of an adhesive joint due to incomplete contact, during bonding, between adhesive and adherend or between adhesive surfaces. ASTM notes that this may be caused by insufficient flow or fusion of adhesive, nonuniform, application of adhesive, poorly fitting adherends, and the like.

Calculating sunlight's "push"

Solar "sails"–space-flight systems powered by the pressure of the sun's rays–may never become practical. But, says H. B. Holl of Marshall Space Flight Center, the mechanical force exerted by solar radiation will have to be considered in computations of satellite position and altitude.

The integrated radiation force (the product of radiation pressure in the vicinity of the earth, times the projected area of the satellite, times a radiation force coefficient which is analogous to the aerodynamic expression for drag) will be less than 2 for plane surfaces and parabolic bodies. The force on spheres will be greater than 0.75, but less than 1.25. Factors for other types of surfaces have also been calculated, and Holl has prepared a report (TND-604) showing factor derivations and giving charts of energy distribution in the sun's spectrum.

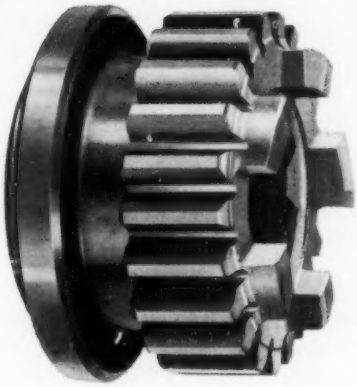
briefs . . .

A glass with unusual heat resistance is reported by S. D. Brown and S. S. Kistler of University of Utah. It's a partly crystalline vanadia-silica composition that seems to resist softening even at temperatures where fused silica is readily drawn into fibers. Oxyhydrogen and oxyacetylene flames glaze its surface–but that's all. Solar-furnace heating studies are now underway to obtain more information on the glass.

Welds in molybdenum are barely half as strong as the base metal, even at temperatures well below 700 F, R. E. Pavlak, M. Christensen, and A. L. Lowe Jr say in reports to the Atomic Energy Commission and the American Welding Society. Indeed, they say, molybdenum-to-steel joints produced by tungsten-arc inert gas-shielded welding are more like high-temperature brazes than fusion bonds. Ductility is poor, too, though it improves somewhat as the temperature is raised toward 700 F. On the other hand, the joints are dense, with no evidence of porosity, so it should be possible to use them where leaktightness is important but high strength is not.

–ARG

Steel that gives cycles a stronger heart



Quick shifts and surges of power put terrific strain on the heart of a motor cycle transmission—the gears. To be sure the gears in all models including the racing models would have maximum strength, Harley-Davidson engineers came to Timken Company steel experts. They selected a special grade of Timken® fine alloy steel for the main shaft, countershaft and main drive gears. Result: Better performance—longer life. The Timken fine alloy steel used has the hardenability that assures maximum core hardness, along with the ductility needed to absorb shock and impact loads. And it has the strength to keep gears meshing more smoothly, more accurately, and longer.

What's more, because we target our processing to your end use, your products will have superior, uniform quality when you use Timken fine alloy steel. Let us show you how. Call or write: The Timken Roller Bearing Company, Steel and Tube Division, Canton 6, Ohio. Cable: "TIMROSCO". Makers of Tapered Roller Bearings, Fine Alloy Steel and Removable Rock Bits.

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Timken Alloy Steel and Seamless Steel Tubing Are Available from Steel Service Centers in 44 Cities in the United States

DEVELOPMENTS TO WATCH...

More data on why parts fail

Specific information on when parts fail and why is beginning to come from a number of independent studies:

1. W. E. Stubbings of Methode Electronics, for instance, reports on an interesting survey of printed circuit connector failures. His data indicate that the most common sources of electrical failure are (in order): contact corrosion or entrapment of moisture; faulty contact between printed wiring and connectors; high contact resistance; and contact fatigue through use or aging.

Primary source of mechanical failure is breaking of the connector body as a result of mechanical shock, vibration, or excessive force loads. Out-of-tolerance parts and broken and bent contacts also cause trouble; and improper or faulty plating results in a good many rejections. This first study was a small one, with only a limited number of companies being queried. But additional studies are now planned to pin down causes and cures and to relate specific problems to specific types of connectors.

2. A recent study of power-supply system components, reported by I. Doshay of Aerojet-General to the last SAE meeting, points up relative reliability of other components. He assigns a reliability rating of about 92.3% to batteries, and 99.99% to resistors, switches, and Zener diodes. Other components, like motors, relays, rectifiers and transformers, show failure rates of 0.067 to 3.09%. Power or voltage derating can significantly increase life of many of them, however.

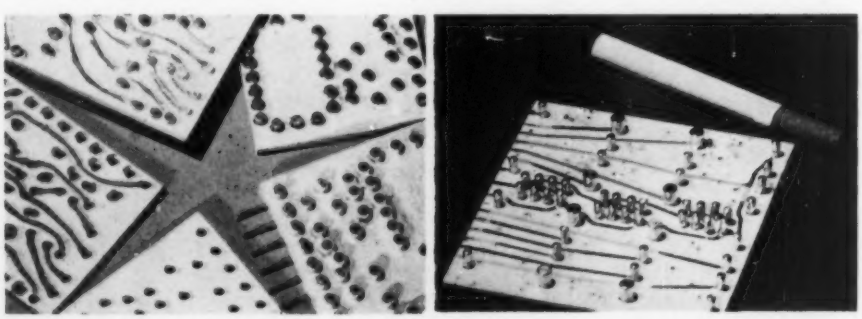
3. For commercial users of semiconductors, at least one manufacturer has recognized extent of the reliability problem by preparing a nomograph to guide design engineers. Raytheon is offering a Reliability Nomograph that makes it simple to compute plans for conventional risks and to convert life-test data to failure-rate predictions at a 90% confidence level. Free copies are available.

(Note: For the latest of PRODUCT ENGINEERING's special articles on reliability, see "Troubleshooter's Approach to Failure Analysis" June 26, p 41.)

This circuit board combines thermal conductivity with electrical insulation

Because equipment designed for space satellite applications cannot enjoy the luxury of air, there can be no cooling by convection; and radiation is of little help at the temperatures at which space equipment must operate. So, new approaches to cooling are needed. One answer: the beryllium oxide printed circuit board shown here. (For another, a "heat shutter," see *PE—Oct 24 '60, p 9*).

Beryllia combines good dielectric properties with unusually high thermal conductivity, and it has desirable physical properties as well (*PE—Oct 17 '60 and Apr 29 '61, p 47*). And, as G. H. Kriss and L. J. Polaski of GE's Missile & Space Vehicle Dept pointed out to the PGEP Conference, it permits design of the electrically insulated but thermally grounded assemblies below.

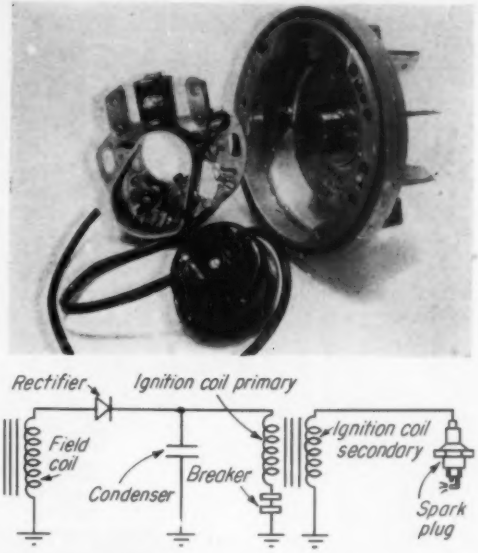


CERAMIC CIRCUIT is assembled this way (clockwise, from bottom). Ceramic body is metallized and fired (left), then brazed and plated (upper left). Next, it's cleaned and the stud faces are ground (upper right); finally, it receives silica coating (lower right). Second photo shows completed unit, compared to cigaret in size.

High-rate ignition system designed in Britain

A master ignition system that's claimed "to meet all the major problems of the 2-stroke engine," and to be applicable to 4-stroke engines as well, is being introduced by Wipac Group Sales Ltd, Buckingham, England.

It's a condenser-discharge unit which, Wipac says, can be produced at competitive cost and used with standard spark plugs. Wipac claims it can operate even at such unusual gas-oil ratios as 4:1 in an engine designed for a 24:1 gas-oil ratio. Furthermore, since the spark is produced as the contact closes rather than when it opens (see photo caption), the rate of condenser discharge is increased and arc time is decreased, thus prolonging the life of points. In addition, timing is reported to be less critical than in the conventional system, and it's less sensitive to moisture and dust.



IN NEW IGNITION SYSTEM. When contact breaker closes, condenser discharges through ignition coil, producing the high-voltage pulse.

New papers to improve electrical laminates

Electrical laminates that "substantially exceed" XXXP specifications, and others offering a high degree of flame resistance and unusual impact strength, are promised by new laminating papers developed by Hurlbut Paper.

One is a 100% acrylic fiber paper which, Hurlbut says, can produce phenolic laminates competitive in properties with Teflon-glass and comparable or lower in cost." Test runs indicate they'll have a dielectric strength in excess of 1000 volts/mil; dielectric constant, 4.0; moisture absorption, about 0.16%.

The second new development is a 100% cotton fiber sheet which, Hurlbut says, is the first successful flame-retardant cotton sheet. It, too, is designed for use in laminates; and, where high impact strength is required, a modification containing chopped glass fibers will be available.

Glass solders and ceramic cements aid design

New designs in vacuum devices, electron tubes and other glass equipment are possible by taking advantage of new devitrifiable-solder glasses and cements, D. E. George and K. D. Earley of General Telephone Labs report.

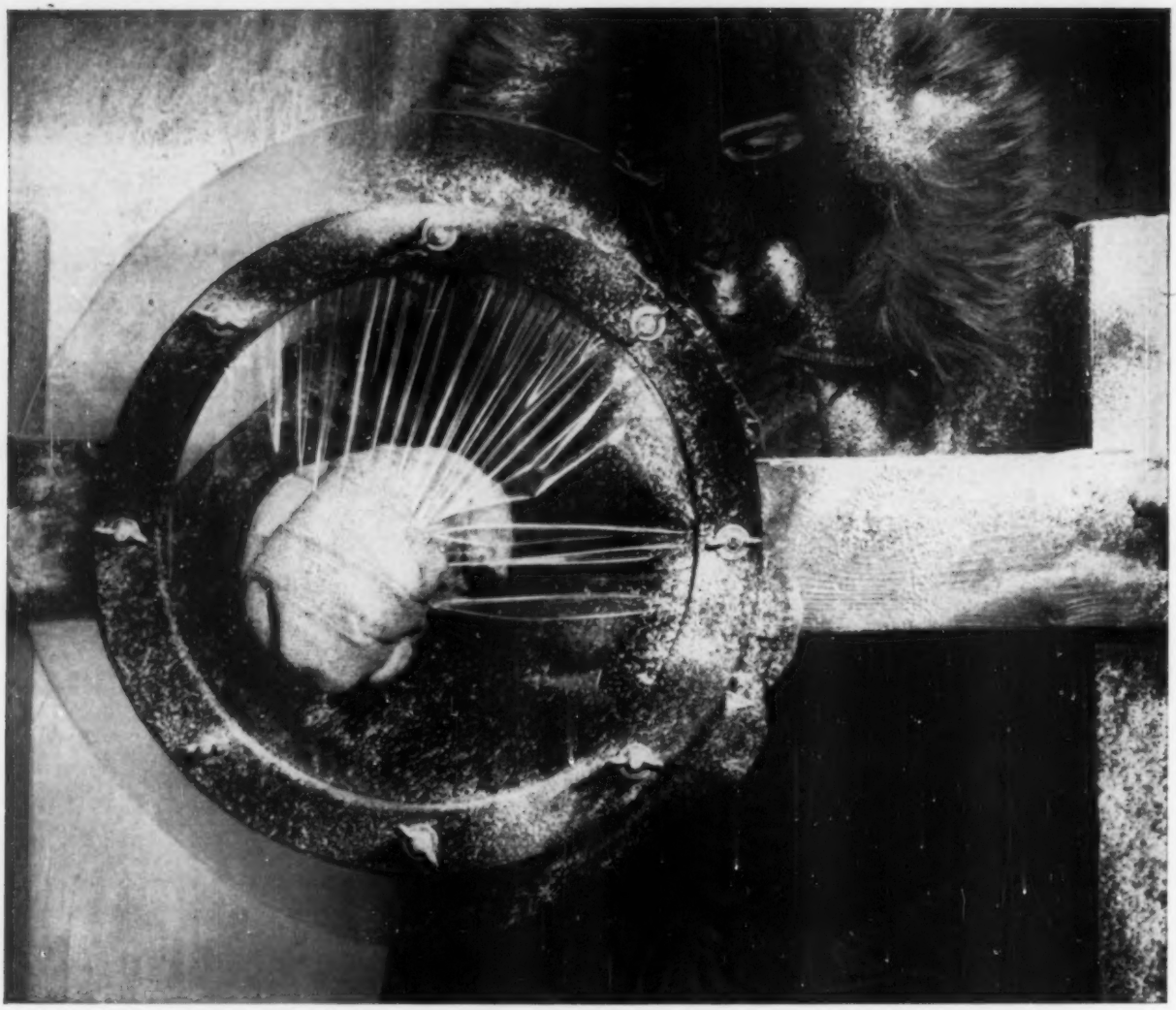
These solder glasses are finely divided frits which, under heat, melt, flow, and cure into glass-bonded ceramic bodies.

There are now several such materials, all relatively new. With them, George and Earley say, even odd-shape vacuum devices which do not lend themselves to regular glass-blowing practices can now quite readily be made.

The Sylvania researchers have been working primarily with low-power microwave tubes, but believe the new cements have much broader possibilities. "Many nearly insurmountable problems of construction," they say, "have been solved by the use of these seals." Other laboratories are working on them too:

Westinghouse researchers H. M. Heyn and K. L. Rohrer are testing a vacuum tube designed for an ambient temperature of 930 F in which Pyroceram 9606 is used for the envelope and one of the new crystalline glasses for the cement. This unit, they say, will stand at least 1000 hr at the operating temperature.

The devitrifiable cements in general, are not serviceable for stringent thermal-expansion conditions, but at least one new solder glass with controlled thermal expansion and unusual heat resistance (setting point, 780 F) is heading for market, and it's expected to broaden design applications still further. —ARG



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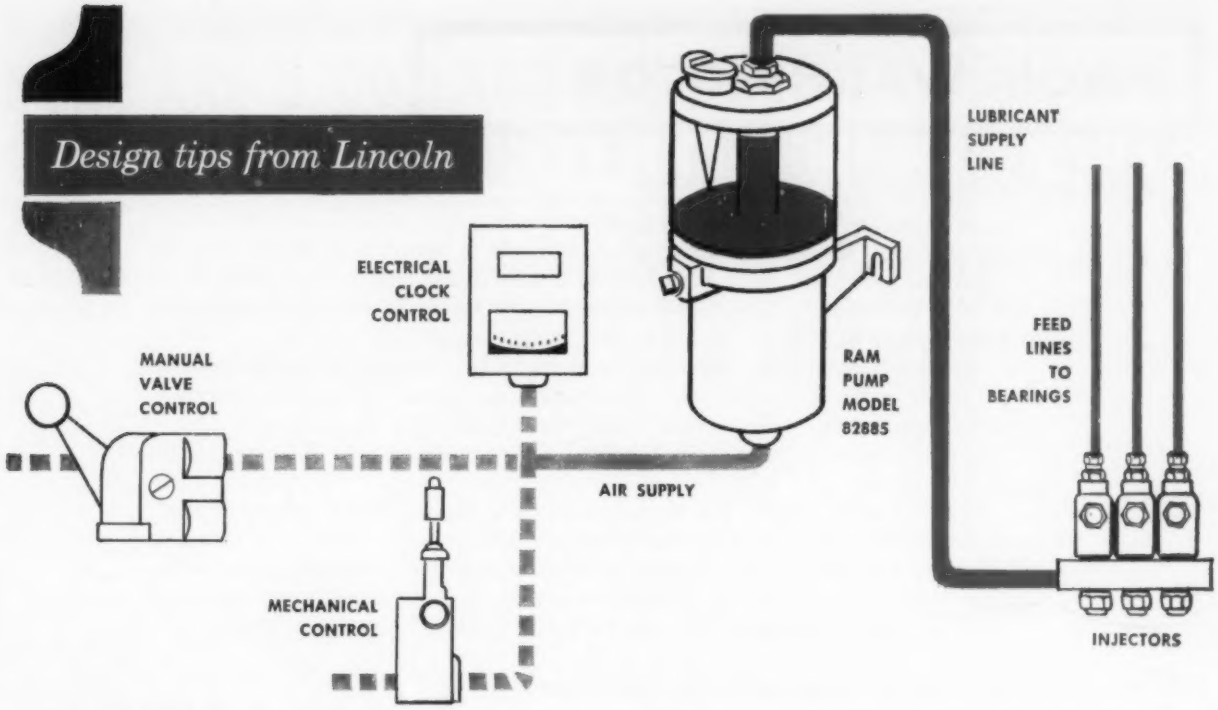
Design tips from Lincoln



The "Milkshaker"... new, compact ram pump for low-cost, automatic lubrication on machine tools

You can use Lincoln's new, compact ram pump for automatic or semi-automatic lubrication on machine tools of all types. This unit lets you design all of the advantages of the large centralized lubrication systems into light, medium or heavy machine tools. It pumps grease or oil, comes in air- or hydraulic-operated models, can be cycled manually, electrically or by mechanical linkage. You can use it to cycle Lincoln's lubricant injectors that measure precise amounts of lubricant and deliver it through a single line under high pressure directly into the individual bearings.

You can mount more than one pump on each machine to handle different lubricants or different cycle frequencies. The new ram pump gives you more flexibility in your design than you would think possible in a low-cost unit.

Note to Manufacturers: Lincoln will help you determine the best automatic lubrication system for your machinery. Contact the Original Equipment Sales Division.

Ram Pump Model No.	Output Per Stroke	Lubricant	Operating Air Pressure
82885 (Air operated)	.45 cu. in.	Oil	35-50 p.s.i.
82961 (Air operated)	1.6 cu. in.	Oil	95-125 p.s.i.
82886 (Air operated)	.45 cu. in.	Grease or oil	70-125 p.s.i.
83110 (Hydraulic)	.45 cu. in.	Grease or oil	50-200 p.s.i. (Hydraulic)

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FROM WASHINGTON...

US patent policy may follow Dutch proposal

A new Dutch proposal for handling patents has created a stir of interest in Europe and the US. Under the plan, patent applications would be published shortly after they were filed, but a patent would not be issued until a necessity for it is shown. For example, if the applicant needed the patent to enforce his rights, he would be able to call the case up for processing.

The theory behind the Dutch scheme is that a large number of patents granted are never used. Thus, the patent department would not waste time processing patent applications only to have them remain dormant. If need to process a patent application is not shown at the end of a seven-year period, the applications will be abandoned.

"The US may be compelled to go to something like the Dutch system", Patent Commissioner David L. Ladd told PRODUCT ENGINEERING **recently.** Currently, there is a 196,000 backlog of patent applications pending before the commission. This amounts to 3 to 4 years of work to process them, Commissioner Ladd says. And, he makes it clear that one way or other he is going to break the log jam.

NASA's in-house research expenditures challenged

NASA plans to contract out over 80% of its estimated $1.7 billion budget for the new year. The agency wants to offset industry charges that too much NASA-sponsored R & D is being conducted in Federal facilities. Latest breakdown of major projects in NASA's program: $72 million, scientific satellites; $159 million, lunar and planetary exploration; $94.6 million, communications satellite; $160 million, Apollo spacecraft; $48 million, Nova super-booster rocket; $36 million, nuclear space propulsion; $224 million, Saturn super-booster rocket; $56 million, Centaur super-booster rocket; $93 million, other liquid-propellant rockets; and $38 million, tracking and data acquisition.

Congress critical of military research management

Congressional criticism of military research management came recently when the House Appropriations Committee took a critical crack at the Pentagon for its mushrooming rate of contracting for "technical management, scientific evaluations, and administrative and management services (in R & D)." The Committee says this practice has boosted costs, is particularly critical of nonprofit research organizations such as the Aerospace Corp. **Says the Committee: "To a considerable extent the use of contracts with non-profit organizations is merely a subterfuge to avoid the restrictions of civil service salary scales."** It cut $5 million out of Aerospace Corp's $35.2 million proposed budget.

In all, the Committee approved a $4.8 billion military R & D appropriation, $52.2 million more than the Kennedy Administration's request. Major beneficiary: The Air Force's Dyna-Soar spacecraft program.

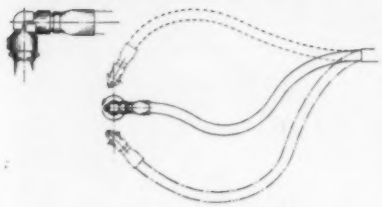
Military contracts may be revamped

The Pentagon is considering a new type of contract to spur cost savings through higher profit allowances in military R & D. Under a proposed "cost-plus-award fee" contract, contractors could be penalized as much as 5% of costs or earn fees as high as 15%, depending on their assumption of risk, technological breakthroughs, product quality and reliability, and other performance factors.

The amount would be determined after the contract's performance rather than during contract negotiations. It would be specified by an independent board of contracting officers who would evaluate the contractor's performance. Under present cost-plus-fixed-fee contracts, profits are held to 5 to 8% of gross.

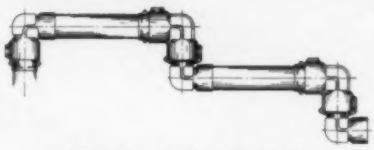
HERE ARE 3 COMMON LINE DESIGN PROBLEMS CHIKSAN SWIVEL JOINTS CAN HELP YOU SOLVE

1 **Shorten hose radii, reduce torsional stress.**



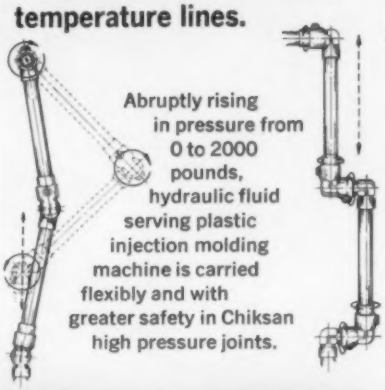
Flexible head on this lens grinder is hydraulically powered. Joints shorten required hose lengths. Hose would otherwise need suspension to keep out of way.

2 **Predetermined flex of piping between two or more points.**

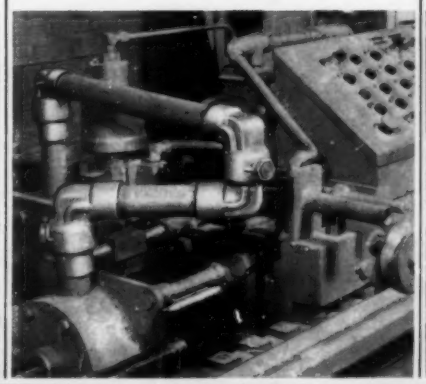


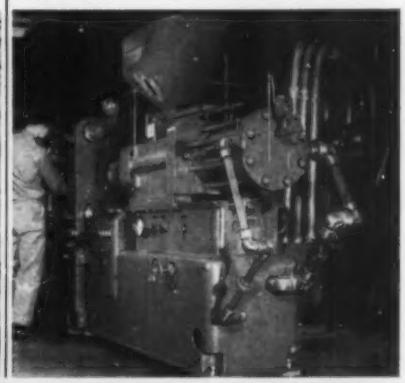
Pressure testing of pipe is nearly automatic as hydraulically driven supply heads close on pipe ends. Dog-leg jointed pipe moves back and forth continuously, safely.

3 **Achieve maximum safety of flexible high pressure, temperature lines.**



Abruptly rising in pressure from 0 to 2000 pounds, hydraulic fluid serving plastic injection molding machine is carried flexibly and with greater safety in Chiksan high pressure joints.





Studied consideration will quickly show that Chiksan swivel joints have numerous applications. Whenever you have a piping situation where movement is required, the benefits of swivel joints should be weighed. As illustrated above, Chiksan swivel joints have great versatility. They give added life and adaptability to rubber hose. They give metal lines a rubber-like flexibility. They help relieve stresses imposed by expansion, vibration or misalignment. Chiksan swivel joints, with their full 360° rotation and high service life, quickly pay for themselves by minimizing hose failures, eliminating costly line failures, fluid loss and downtime. Chiksan swivel joints have a wide range of pressure and temperature ratings to meet most industrial applications. There is a nearby experienced representative who will call, analyze your requirement and make specific recommendations. Write today for his name.

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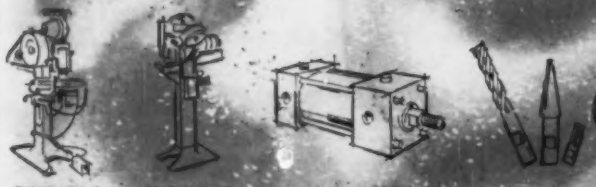

RIVITORS CLINCHORS CYLINDERS CUTTING TOOLS

T-J TOMKINS-JOHNSON
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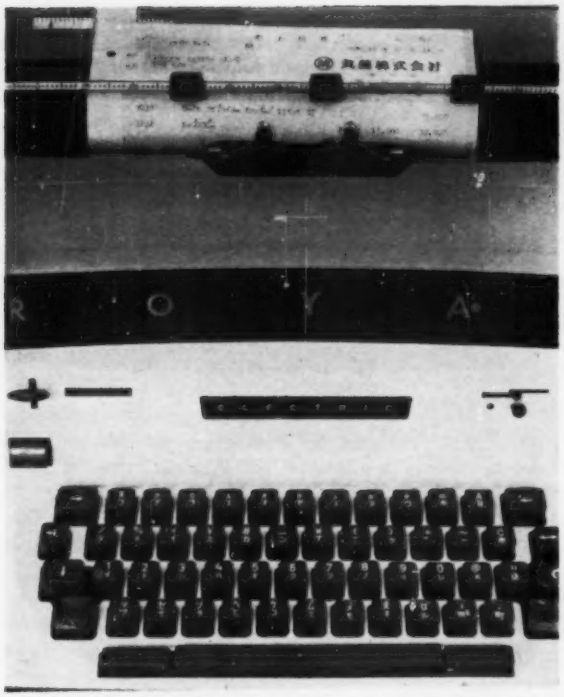


ELECTRIC TYPEWRITER, made in the US, by Royal has a "katakana" keyboard—the symbols of foreign words introduced into Japanese. Manual models of the machine sell from $260; electric up to $680.

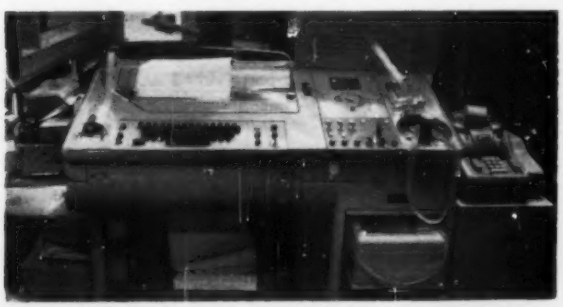
JAPANESE typewriter, prints copy on the cylindrical roll above the table. Its operator selects one of 3000 or more characters in the table, moves an indicator over it, and then punches it to get an image on the paper.

Japanese designers make solid progress with new business machines

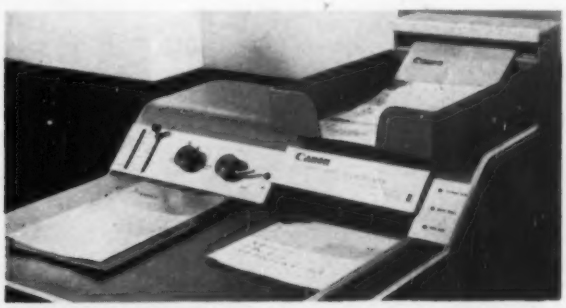
Tokyo—Business machines are increasingly essential to Japanese offices, and engineers here are meeting the requirements with a wide range of new equipment—some of it adaptable to the export markets. The strides being made were dramatically displayed at Tokyo's 22nd annual business show where some 10,000 products, ranging from pencils to computer systems, were seen by more than 200,000 visitors to the permanent downtown fairgrounds.

The pressure to develop office machines stems from a labor shortage brought on by Japan's booming economy. This shortage is compounded by traditionally inefficient use of human resources—the product of being an "overpopulated country" for many years. With customary practices, an increase in paperwork that could be easily handled by a western office becomes an enormous chore here.

For the foreign viewer, the real eye-catchers were the copying machines, that ranged from highly sophisticated designs by Japan's world-famous camera makers to traditional silk-screen processes, more than a thousand years old. Copying machines are essential in Japanese offices be-

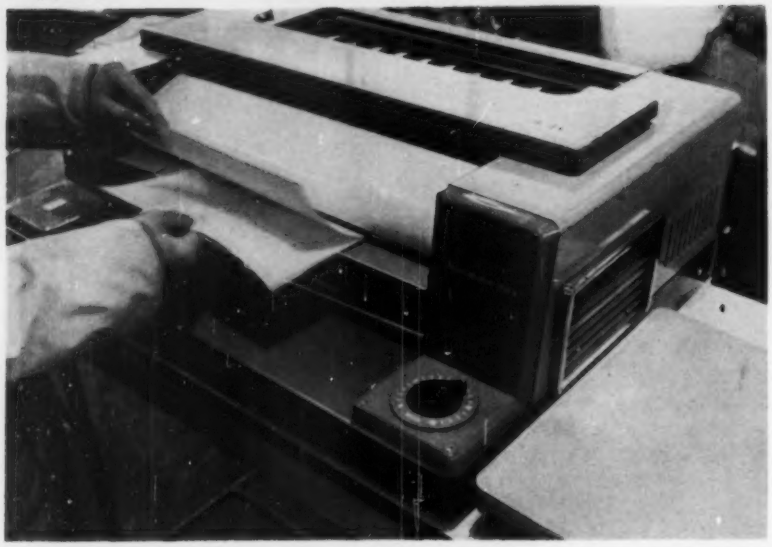


COMPUTER by Oki Electric Co's is the first entirely-Japanese system with all components for programming and making computations. The company will not release further details at this time.

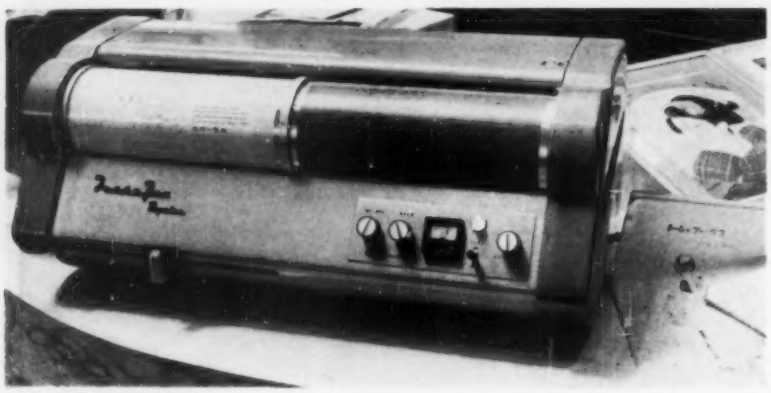


MICROFILM CAMERA is made by one of Japan's famed 35-mm miniature camera makers, Canon. It sells here for $1600, and the company may export it. Generally export prices are well under domestic.

Copying machines dominate show



INFRARED LIGHT—Ricon's Ricopy machine uses photosensitive paper, which is unaffected by light but takes an imprint from an infrared light source in the machine.



STENCIL COPIER—the Tosha-Fax by Tokyo Aeronautical Measuring Instruments Co, makes a mimeographed stencil of original. Transfer is accomplished photo-electronically. The cylinder turns with the original attached to one end of the drum and the stencil to the other. Process takes about 8 min.

DRY COPIER—This direct-copy system combines a printer and processor for dry-copying. It is made by Fuji, one of Japan's largest film producers.

cause the language has so many characters—a daily newspaper, for example, uses a minimum of 1500, plus over 100 additional characters representing syllables.

So while the Western typewriter is not adaptable to Japanese, the Japanese copying machines are doubtless adaptable to Western offices. It seems only a matter of time before they make their way into the world markets.

$11 MILLION EXPORT SALES

Already, Japan's small and medium industry (the term used for labor-intensive, capital-short small manufacturers) are selling a variety of office supplies abroad. Last year these exports, including punchers, electric erasers, stampers, etc, totaled $11 million. Now, they are being followed by more complex products, as for example, the sheet recorder which also serves as a telephone recorder and memo pad.

Camera companies showed new models of microfilm cameras and reproduction devices, bearing brand names that have already become familiar trademarks in the 35-mm market. One company also showed a 16-mm film projector with a light-diffusing screen; hence it can be viewed like TV in a lighted room—an excellent device for factory and business presentation.

US COMPUTERS ON VIEW

The international computer companies—Remington Rand, International Business Machines and National Cash Register—participated in the show along with local manufacturers at a special computer center. Star of this display was a new computer by Oki Electric company—the first Japanese firm to show a complete system with programming techniques.

About 30% of the exhibits were products of foreign firms that hope to move quickly into the fast-developing Japanese office equipment market. Last year this country imported $53 million worth of such goods. With the promised "liberalization" of imports, the figure should climb rapidly. Already, during Jan-March of this year, import of office equipment were up 30% over the same period in 1960 with greater increases forecast for the remaining three quarters.

—Sol Sanders, Tokyo bureau

New machine-tool designs now dominate Hungarian exports

BUDAPEST, HUNGARY—This country has transformed itself from a predominately agricultural to a highly industrialized nation since 1948. Striking evidence of the metamorphosis is shown by a machine-tool industry which can now export as well as supply local needs—although, to do this, local requirements often bow to export orders.

The government is anxious to increase tool exports and reports that some 52% of Hungary's machine-tool production now goes abroad. These exports are valued at about $16.8 million and accounted for 37.9% of the country's trade in 1960. The tools find buyers not only in the East, but in such Western nations as West Germany, Italy and Brazil.

Quantitative and qualitative standards for the industry are set by government and these have design implications. Engineers are told to design "machine-tool families." They are also told to make them light in weight. Weight is emphasized, in part, to compel engineers to think in modern construction terms and also to help cut imports of scarce materials. The industry is so new that an estimated 60% of all the tools have been designed within the past 3 years.

Another characteristic of tool design here is extensive automation of loading and transfer operations—standard machines are being fitted with cycle-work attachments. But automation is running into some troubles. A production bottleneck exists because electronic and hydraulic components for program control have to be made by the machine-tool plant itself. Specialized factories do not yet exist. And users sometimes cannot make full use of such equipment because they have few maintenance personnel, and delivery of spare parts is slow.

Newest of the machine tools were on display here recently at the annual Budapest fair, where the largest exhibition hall was turned over to the two dominating export industries: instruments and machine tools. Featured in the exhibits were prototypes by Hungary's Machine Tool Research and Development Institute (SFZI). Its exhibit included:

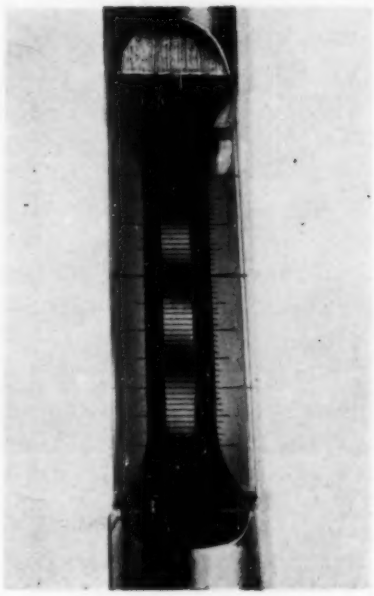
- An automatic machine for balancing rotating electrical components such as rotors with windings. The machine is divided into four stations: The first is the feed unit; the second, a measuring unit to detect and mark imbalance, both by vibration perception heads and dynamos that rotate synchronously with the work object; the third drills superfluous material away; the fourth delivers piece to automatic or manual transport.
- Semiautomatic turret lathe designed to machine automatically according to a numerical control program stored on a 100-line drum. The unit has 6 spindle speeds ranging from 45 to 2000 rpm, and 9 sliding feeds. It has one longitudinal and two cross-tables—both hydraulically operated. The automatic control is all-mechanical, without electronic components, transistors, ferrites, etc.
- Semiautomatic copying lathe, designed for turning shafts held between centers. Templet masters are used and machining is automatic. Loading and unloading equipment can be attached to fit the unit into transfer lines. Four spindle speeds ranging between 56 and 250 rpm are available. Sliding feed is infinitely controlled from 1.09 to 24.57 inches per minute.

Production of machine tools is concentrated in 7 plants, and these also displayed prototypes at the fair. Cespel Machine Factory, a producer of milling, drilling and single-purpose machines, and automatic and transfer lines, showed a prototype of its new automatic cutting tool, the MC-1. Up to 10 different cutting-tool holders can be milled on it. The operation starts with a steel bar, 9.84 x 0.98 x 0.62 in., which is inserted in a hydraulic jaw for alignment. At the first work position a horizontal milling head faces the bar; at the second, a radially mounted inclined milling head machines it; at the third, one edge is milled according to Hungarian machine-tool specifications; at the fourth, a vertical milling head machines the top side; and finally at the fifth a milling spindle cuts out space for inserting the hard-metal tip. Output is 180 to 200 units an hour. A similar machine fitted with grinding accessories is planned to supplement the milling unit. It will set hard-metal plate to tool holder, surface grind the tool (tip and holder), rough-finish two vertical sides and finally fine-finish all five sides. The pair is expected to be commercially available in 1963. Meanwhile, Cespel is seeking licensees in either East or West.

The Dimavag Machine Tool Works, a producer of single-purpose machines, particularly lathes, showed its prototype of a 4-position unit for machining heavy bearing cups—the KCC-5/10. This semiautomatic unit mills,

engineering week continued on p 20

Fringe movement checks alignment of test machine



A PhotoStress transducer developed by the Instrument Div of The Budd Co reads pure tension, and also bending in two planes to permit accurate alignment of testing and fatigue machines. The simultaneous measurements are given by the displacement of two systems of frozen-in fringes. Budd claims the instrument can determine amount of pure tension in the specimen, hence serve as a load cell; can check proper alignment of the specimen; can determine specimen-bending in two planes; and determine the presence of parasitic torsion. The sensitivity is adjustable by changing the type and thickness of the photoelastic plastic, as well as the type and geometry of the metal specimen to which the plastic is applied. A calibrated scale indicates directly the load in pounds on the specimen. Same principle can be applied for compression and bending samples, or any other loading condition.

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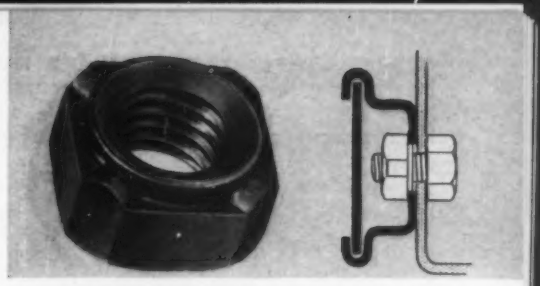
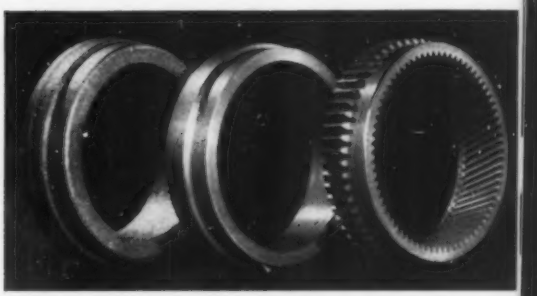


BLIND FASTENING APPLICATIONS are no problem with Republic Midland Weld Nuts—newest addition to the more than 20,000 different types and sizes of Republic Fasteners. They save time, cut costs. Simply premount in places where a wrench can't reach, spot weld in seconds with standard projection welding equipment. Circular pilot guides Republic Midland Weld Nuts into position, protects threads, simplifies automatic feeding. Send for data.



ABILITY TO WITHSTAND SEVERE SHOCK, strain, impact, and wear were important factors in the selection of Republic Hot Rolled Alloy Steel for planetary ring gears—product of Warner Gear Division, Borg-Warner Corporation, Muncie, Indiana.

Records prove that the uniformity of this alloy steel has reduced reject rate and scrap loss. This, along with exceptionally high machinability, is holding unit cost of the planetary ring gear to an absolute minimum. Send for data on Republic Hot Rolled Alloy Steel.

EASY TO FABRICATE, bend, flange, weld, Republic ELECTRUNITE® Stainless Steel Tubing is ideal for a variety of design and engineering requirements. Republic combines leadership in the production of welded tubing, and in stainless and alloy steels to give you close-tolerance I.D. and O.D. concentricity, uniform metallurgical and mechanical qualities. Call your Republic Representative for fast service—price and delivery quotations to you within 24 hours. Mail coupon for more information.

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- ☐ Fastener and Formed Parts "Specials"
- ☐ Alloy Steel
- ☐ ELECTRUNITE Stainless Steel Tubing
- ☐ Republic Midland Weld Nut

Name_____ Title_____

Company_____

Address_____

City_____ Zone_____ State_____

drills and reams about 40 pieces of cast alloy (Al-Si-Mg) an hour. The rotating table is hydromechanically controlled; it is 39.37 in. dia and divided into 5 clamping jaws.

Another interesting Hungarian development is a small oil-pressure turbine that drives small internal-grinding tools. It operates continuously up to 100,000 rpm; turbine life is well over 1000 hr. Key to design is selection of perfect small-diameter steel balls for the ball bearings, which rest on the inner bore directly on the turbine shaft. Oil vapors created by the turbine, cool and lubricated the bearings.

Fred Baer, Regional Editor

Next ship for Mohole will automate operations

HOUSTON—One of the major problems to be solved in the next phase of the Mohole program will be automation of various operations, Willard Bascom, director of the project said here. For example, he noted that forces of wave action on the ship and motion of the drill pipe at greater depths than reached during the first operation will require a considerable degree of automation of "all the major activities" on the drilling floor. This applies particularly to making up and breaking out drill pipe. A substantial amount of wireline operations also will be needed.

Included will be such design features as roll damping tanks, a deep keel for stabilization, in addition to automatic controls for holding the ship in position, Bascom added.

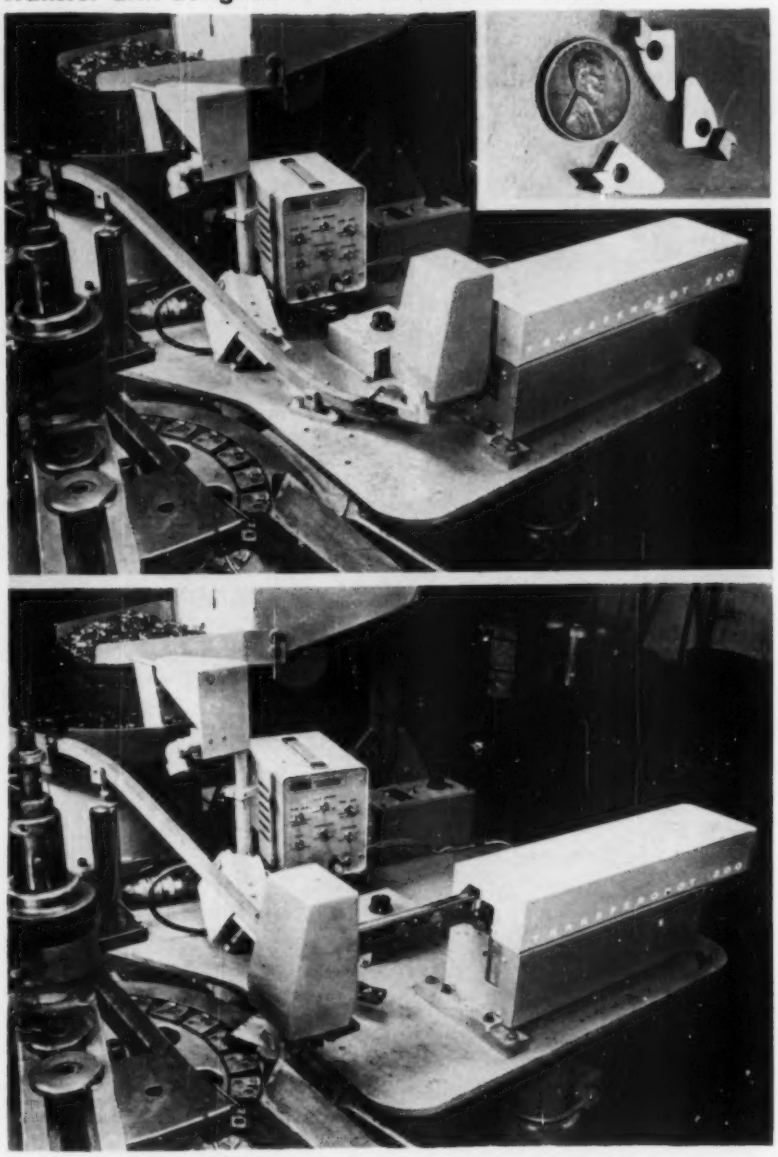
One of the "toughest single problems," he said, is to design pipe casing running from the ocean floor, practically to the surface. The drill string will work within it. Problems include type of casing, method of anchoring, etc. The initial test drillings this spring used only a short piece of casing at the ocean bottom to keep the drill string from snapping. (*PE—Feb 13, p 13.*)

Bascom said an "intermediate" type of drilling vessel is being designed now to carry the program foreward, with a target date for commissioning about a year from now. This ship, he said, probably will be capable of 20,000 ft of total "pipe reach" from ocean floor to surface. The "Moho ship" for final stages of the project is some three years away, says Bascom.

The program, he said, has cost about $1½ million so far. Among significant results up to now is determination that seismic waves travel through soft sediments more quickly than expected. This tends to revise previous thinking about the thickness of the crust beneath the ocean. Bascom said that temperature surveys had borne out previous expectations.

—Glenn Green, Houston Bureau

Transfer arm designed to use off-the-shelf hardware

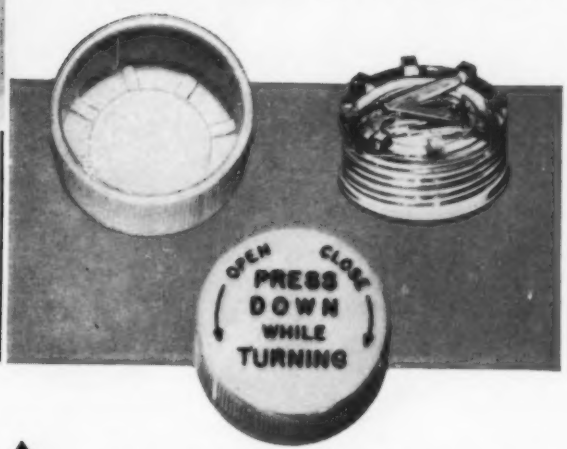


The problem of moving parts in repetitive operations from machine-to-machine or place-to-place may be simplified with US Industries TransfeRobot. This versatile machine uses two mechanical cams, two stops and a microswitch to control arm motion and sequence of operation. An electrical drive combines with simple mechanical linkages to transfer parts of about 1 lb average weight through 10 in. of vertical motion, 2 in. horizontal motion, and 360° rotation. The moveable microswitch on the traveling arm can be set to actuate other units or machines in the system. Sequence photos show device in operation at Underwood Corp Hartford, Conn plant. Jaws pick up typewriter components (inset) as delivered from feeder, and transfer it to an automatic countersink machine. Controller, using solid state logic circuitry, can operate machine as well as signal other arms in the system to do a definite task. US Industries says the production line device is commercially available; sells for $2500.

NEW DESIGN WITH TWO PLASTICS ...A CHILD-SAFE BOTTLE CAP

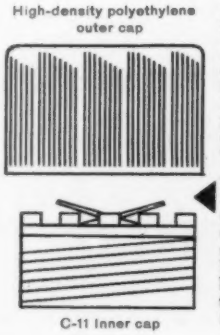
Two BAKELITE® Brand plastics work together in a totally new, much-needed cap for medicines

97% of pre-school children tested couldn't open this bottle cap—Since hundreds of young children are poisoned every year by medicines taken accidentally, this percentage is significant. According to the manufacturer, Brockway Glass Company, the safety cap, which looks like a conventional bottle cap, is "the first major improvement in prescription packages in fifty years." Unique in design, it must be pressed down and turned to open—operations that children five and under can rarely perform simultaneously. For them, the cap turns freely without unscrewing from the bottle.



Keep an eye on packaging—it's one of the liveliest areas of design and a source of refreshing ideas. Not only must it keep pace with changing esthetic concepts, but it also involves practical mechanics. This is often the reason why packaging designers have made such bold use of plastics in working out their plans. Plastics can provide properties that differ from those of conventional materials. And since there are differences among plastics, the range of possibilities is far-reaching.

Under the BAKELITE Brand, for example, you can select from five different classes of plastics to fit your needs—polyethylenes, epoxies, phenolics, styrenes, and vinyls. Molded, extruded, laminated, and in coatings, they can be a source of genuine product improvement. And from Union Carbide, you can get expert technical assistance in putting them to the best use. For information, see Sweet's Product Design File, section 2a/ui.



Two plastics help make this design workable—Manufactured for the Brockway Glass Company by Seals, Inc.,* the new safety cap consists of two parts—an outer shell molded of BAKELITE Brand high-density polyethylene, and an inner section molded of BAKELITE Brand C-11, an acrylonitrile-styrene copolymer. There are multiple advantages to this combination—eye appeal, low cost, resistance to chemicals and stress cracking, and durability. The toughness and resilience of both these materials are important mechanical features. Lugs on the inner cap engage those inside the outer cap when pressure is applied. Without pressure, the two leaf springs molded on the inner cap keep lugs from engaging, and the outer cap turns without opening.

Molded details in two tough materials are key to function, low cost—Both the BAKELITE high-density polyethylene and the BAKELITE C-11 plastic used in the cap have a degree of "give"; they are neither brittle nor soft. It is this factor that makes the lugs disengage unless pressure is applied, and it also means that the lugs will not break off or wear down with repeated use, as might happen with a brittle material. The list of molded-in details is impressive—screw thread, lugs, leaf springs, printing, knurling—yet all are readily formed in these plastics with a simple, economical molding operation.

*U.S. Patent No. 2964207

UNION CARBIDE

BAKELITE and UNION CARBIDE are registered trade marks of Union Carbide Corporation.

Dept. JM-113G, Union Carbide Plastics Company
Division of Union Carbide Corporation
270 Park Avenue, New York 17, N.Y.

Please send me information on the use of BAKELITE Brand Plastics in design with particular emphasis on these properties_____.
Application being considered is_____.

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FIRM NAME _____

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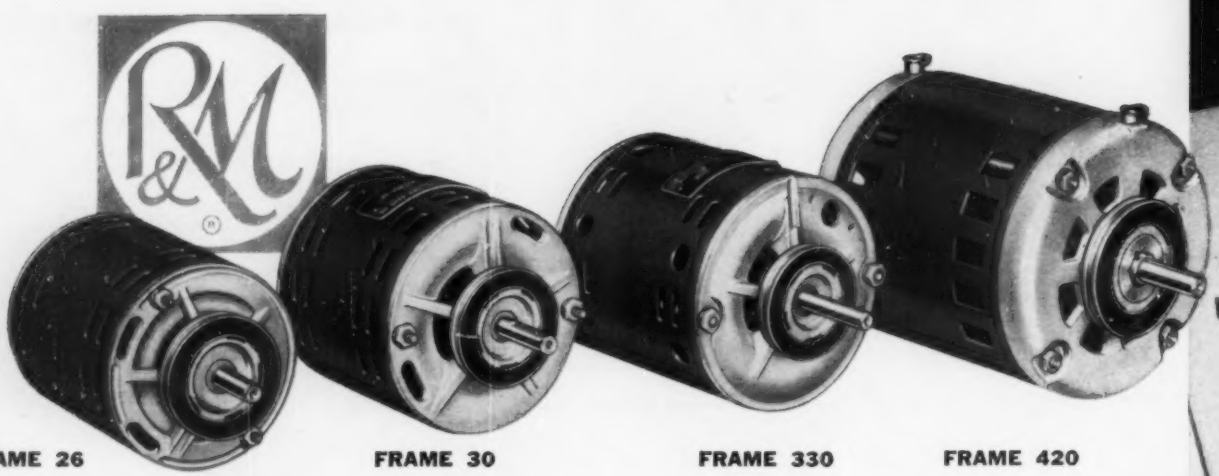

FRAME 26 FRAME 30 FRAME 330 FRAME 420

new broad line offers ratings from 1/100 through 1/3 hp!

R&M's Special Application AC Motors feature extra dependability for your customers and offer wide design flexibility to you! Silent operation, compact size and minimum maintenance make these FHP motors ideal for powering office appliances, fans and blowers, small motor driven tools and countless other products. You can select from four frame sizes, 3" through 4¾" dia.; sixteen ratings from 1/100 through ⅓ HP; two, four and six pole speeds; three mounting arrangements; and four electrical types—capacitor start induction run, split phase, permanent split capacitor or polyphase.

For long-life operation, Mylar is used to line the burr-free slot cells. Mylar has 8 times the dielectric strength of conventional insulation and stubbornly resists tearing and aging, to provide virtually permanent protection. Venturi baffles in each end head direct fan-driven air over and around coil ends in a "washing" action that quickly carries off heat, keeping the motor well within its rated temperature rise. The absence of centrifugal mechanisms and brushes further minimizes maintenance problems.

R&M Special Application Motors are available in standard off-the-shelf designs. Should you require a special custom motor, R&M will recommend the optimum design, at no obligation. Write today for new R&M bulletin 445-PRE

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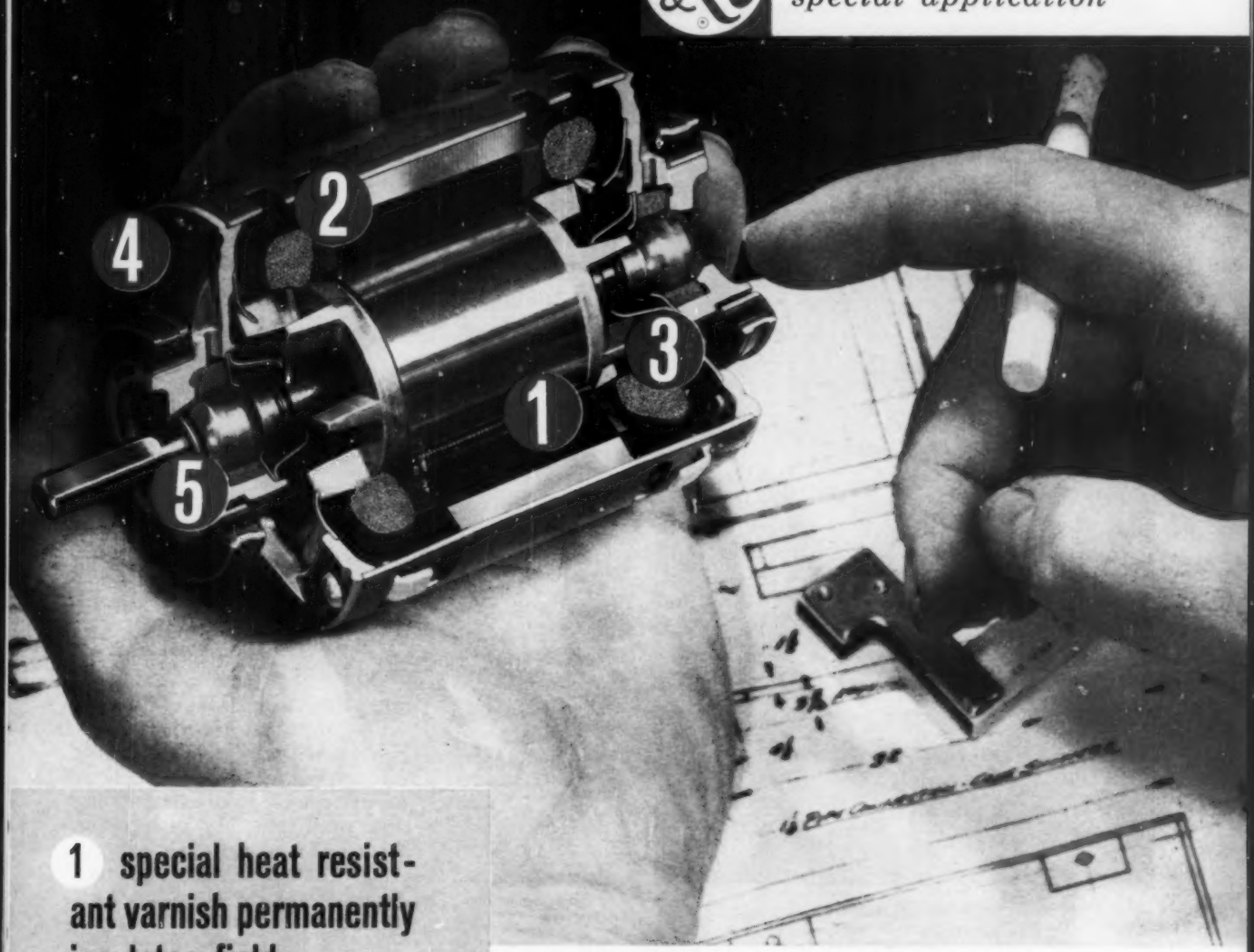
Propellair® Industrial Fans • R & M-Hunter Fans and Electric Heat • Trade-Wind Range Hoods and Ventilators
Subsidiary companies at: Memphis, Tenn., Pico Rivera, Calif., Brantford, Ontario.

R&M

FRACTIONAL MOTORS

special application



1 special heat resistant varnish permanently insulates field.

2 Mylar* insulation locked in burr-free slots.

3 high velocity air flow cools motor windings.

4 lightweight, die-cast aluminum end heads.

5 choice of sleeve or ball bearings.

*DuPont registered trademark.

round body with resilient rings

round body without resilient rings

mounting styles

rigid base mounting

resilient base mounting

CIRCLE 23 ON READER SERVICE CARD

POINTS OF VIEW

THE QUESTION: *Must the product*

James D. Bowles
Manager, Tape Unit Div
Ampex, Computer Products Co

James D. Bowles joined Ampex Corp in 1954 bringing to Ampex a broad background in both engineering and management. After working with the United States Rubber and Illinois Steel Corporations, he served as Chief Engineer for the Mission Appliance Corp from 1950 to 1954. His university education has included study at Kansas State College in Electrical Engineering and additional work in Business Administration and Education at Indiana Univ. During his seven year association with Ampex, Bowles has held a number of administrative positions, and at present is Manager of Ampex Computer Products Company's Tape Unit Div. The division specializes in the manufacture of tape memory systems used in the computer industry. —W B W

Redesign or begin anew? This question has been argued by every chief engineer, sales manager and company president. Here is an engineer's approach.

■ All too often, modern designs are conceived in the spirit of uniqueness rather than meeting the need for functional excellence. By this I mean that far too many designers prostitute professional morality for sales expediency.

"Give us a gimmick edge over the competition," is the plea of the sales department. "Give us a sales lever," they say. "It doesn't have to be better . . . just make it different!"

Company management is also guilty of nurturing the downgrading of design honesty. Far too many companies equate change to progress. They consider any change to be an advancement and pressure their engineering departments into unsound or premature changes in the illusory hope of creating a corporate image of progressive leadership. The result . . . an unforgivable waste of engineering talent that could be better spent debugging and upgrading existing designs to optimum performance. And there is a direct monetary loss also. Disillusioned customers turn from spurious "advancements" to more reliable products.

The era of glamor in design is upon us and can largely be attributed to the Missile and Space Age. Bizarre new materials, exotic fuels, electronic brains . . . all have helped to foster the fantasy that only the new and different are worthy of consideration. The complex and rapidly changing character of missile design has added another dimension to the over-all design consideration that exaggerates the urgency for newness. How many times has the decision been made to eliminate the cost of design maintenance on the assumption that next year will see the design obsolete? The minor design errors or inconveniences are tolerated in the expectation that the basic design will be replaced by a new concept in the near future. The pressure of expediency forces maximum effort to be expended in the creation

be redesigned every year?

of new concepts—to the near exclusion of intelligent redesign that would upgrade existing concepts.

Manufacturers are certainly not alone in their guilt. The product customers demand the very latest in the state of the art. A new tape recorder must have the highest obtainable band pass. It must have the highest signal-to-noise ratio and the lowest flutter. If it turns out that the operator has to reach over the console and give the reel a little spin to "sync-in," or if after a limited number of hours some adjustments have to be made, or if before each test is run the recorder has to be calibrated—all this can be lived with as long as the basic technology is the latest. I think that the bulk of the instrumentation designed in the past few years has been conceived on this basis. The designer could never completely design his product. Before he got the bugs worked out, the customer was pressing for deliveries—the designer was required to deliver in 9 months instead of 18. Everything was on a crash basis. It is truly remarkable that some of the designs work as well as they do.

I don't wish to imply that research for new concepts should be sacrificed in a zeal to improve existing designs. Research is essential for company growth, but what I do emphasize is that existing designs should be brought up to their highest reasonable capability before being junked in favor of new concepts at an inferior stage of development.

I personally believe any company that does not emphasize reliability and performance per dollar is perpetrating dishonesty upon its customers. Reliability can be emphasized and performance cost can be reduced only by spending more time on the evolution of proven designs.

Everyday we are confronted with examples of change for change's sake. The automotive industry is probably the most obvious offender. Each year, on a regular schedule, the Detroit designers spend a phenomenal amount of engineering talent to create changes instead of improvements. Frequently, the changes are not only non-improvements, but a backward step as well. One example that comes to mind is a fancy gimmick for selecting automatic-transmission drive positions. This "revolutionary" change not only fails to be an improvement over the conventional selector lever, but is awkward and less flexible to use.

Foreign cars have also taken up this wasteful trend. The one salient exception is Volkswagen. VW has an announced and practiced policy of making no changes except to significantly improve the car. These changes are not made on a fixed schedule, are made only after they have been proven reliable according to the VW policy. While business has declined for all other foreign automobile manufacturers, VW has continued to increase its sales in this country.

This is a healthy trend that should be taken up by all industries—more effort to improve the existing and less emphasis on being different. Of course, even this well-founded policy can be carried to extremes. The American sewing machine industry is a perfect example. For decades, no changes were made in the basic design. Then, right after World War II, foreign sewing machines invaded the American market with completely new concepts and dealt a severe blow to our manufacturers. Americans were forced to create competing designs in a hurry. The expected results occurred—some inadequately tested designs failed in service and customer confidence was reduced.

Another design waste that runs parallel to unwarranted changes is the penchant some companies display for overdesigning. The simple, straightforward approach seems to be abhorred as an indication of technical incompetence. Again, the automotive industry is a prime offender. Large expanses of windshield glass in convertibles are supported by beef-up frames and tricky innovations concealed in the body design. In contrast, one manufacturer, Mercedes-Benz, has the courage to approach the problem with a simple and logical solution. In its model 190SL, it places a slender steel rod in the center of the windshield, running from the top of the frame to the instrument panel. The windshield is adequately supported and driver vision is not appreciably impaired.

Awe and reverence for esoteric technology and the constant expectations for something new are slowly and surely being replaced by demands for more reliability and operational excellence. How the manufacturer can give his customers more honestly designed products would fill many volumes of text. But the basic precept can be summed up in one sentence: More true advancement and value will be found in upgrading an existing design than in a myriad of untried new concepts. ■

HANDY & HARMAN SILVER BRAZING
Permits Manufacturer to Guarantee Underwater Air Regulator For Life

Perhaps the most vital component of a skin diver's equipment, this Viking Air Regulator, manufactured by Christensen Tool & Engineering Company, Norwalk, Connecticut, is structurally guaranteed for life. It must, under all conditions, be absolutely leaktight. The manufacturer's guarantee is a relatively recent achievement—through the high-strength help of silver alloy brazing with Handy & Harman EASY-FLO 45 and HANDY FLUX.

Over and above the unreserved dependability of brazed joints, the brazing method itself has saved the company considerable time, money and material in the production of the Viking Air Regulator. Brazing's simplicity is interestingly illustrated in this case by this company's requirement that assemblers and testers of the Viking must be skin divers themselves.

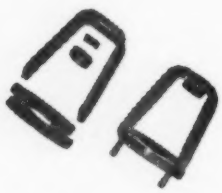
Almost invariably, silver brazing effects economies and brings advantages to whatever part, product or assembly it is applied. True, air regulators are few and far between, but the point is that they are *metal products, made of a number of different metal components.*

And that's the phrase that covers brazing's great adaptability. To give you a good idea of how you can put brazing to work, we'd like to send you Bulletin 20—it covers the basics of brazing and it may very easily solve your metal-joining problems. Handy & Harman, 850 Third Avenue, New York 22, N. Y.

Here, in "serial" form is how the guarantee is "brazed" into the Viking:

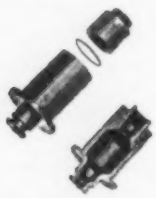
1. TANK HOUSING—Initially, this component was mechanically joined and made "airtight" by means of sealants. Now, brazing eliminates 8 holes, 4 tapping operations, 4 screws and 3 assembly operations.

5. Shown here are the finished Viking components before and after assembling. —Brazing by Specialty Brazing Laboratories, Riverside, Connecticut.



3. YOKE—This is assembled from stampings instead of castings, which were previously used. With brazing, no secondary finishing operations are required. Further, the part is stronger and lighter, and savings on material and labor on this component alone add up to 28%.

2. FORK ASSEMBLY—There are five separate brazed joints, done with hand torch and hand-fed wire. Brazing eliminates one tapped hole, a lock washer and a spacer, plus the fact that positive alignment is now guaranteed.



4. PISTON—This is the most important single element of the Viking. It regulates flow of oxygen from cylinder to mouthpiece; from 300 lbs. pressure to normal breathing. Without brazing, this part could not be made.

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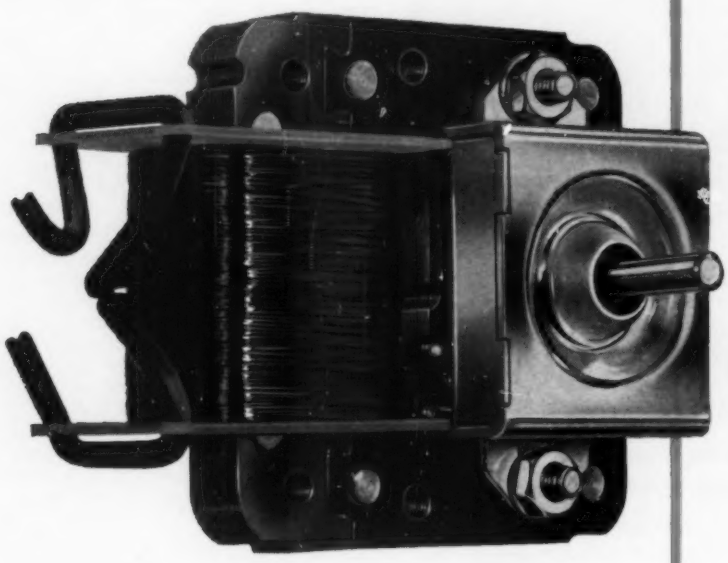
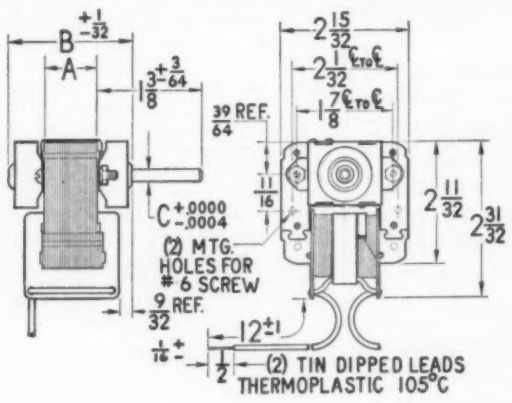
NEW TYPE EA1 UNIVERSAL SKELETON MOTOR

a superior unit because of quality construction, larger bearings and greater oil capacity



- Larger bearings and greater oil-felt capacity give longer motor life.
- Grooved bearings insure continuous oil return.
- Larger bearings reduce motor noise.
- Accurate metallurgical control of laminations insure uniform performance.
- Interchangeable mountings.
- Six standardized models, 1/500 to 1/45 HP.
- The correct motor for rotisseries, vending machines, office machines, chart drives, phonographs, slide projectors, heaters, refrigerators, hair dryers, deodorizers, 2" to 8" diameter fan blades, electronic equipment, etc. Write for complete specifications on your requirements.



SPECIFICATIONS

UNIVERSAL TYPE EA1 SKELETON MOTORS 115 VOLT 60 CYCLE

MODEL	HP @ 2,800 RPM	MAXIMUM TORQUE oz. in.	DIMENSIONS		
			A	B	C
EA1A	1/500	1.1	3/8"	1 53/64"	.1817
EA1B	1/350	1.4	1/2"	1 61/64"	.1817
EA1D	1/130	3.3	3/4"	2 3/16"	.1817
EA1E	1/90	4.5	1"	2 7/16"	.1817
EA1G	1/60	6.5	1 1/2"	2 15/16"	.250
EA1J	1/45	7.5	2"	3 7/16"	.250

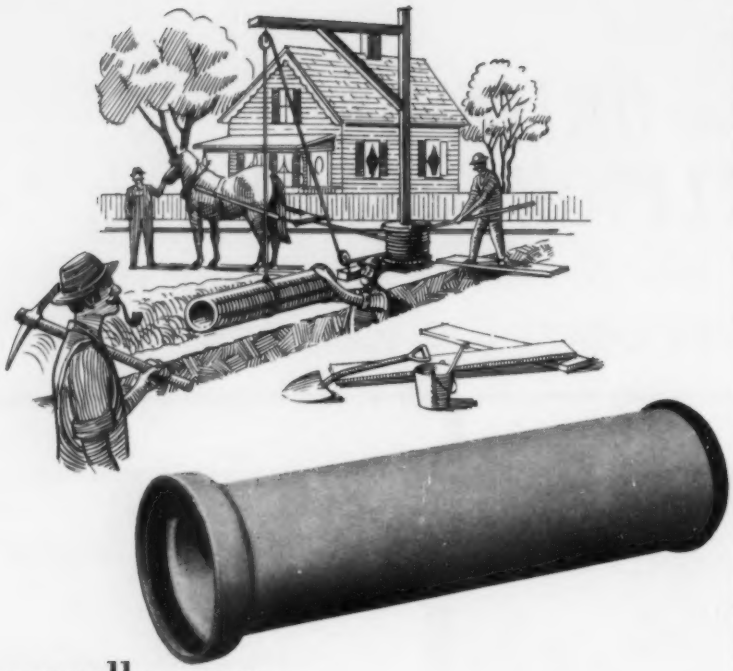
12" leads on all models

57

UNIVERSAL ELECTRIC COMPANY

PRECISION ELECTRIC MOTORS

EXECUTIVE AND GENERAL SALES OFFICES: OWOSSO, MICHIGAN, DEPT. 12



It usually pays to TAKE A SECOND LOOK

. . . even at products which have long been considered "perfected".

Vitrified clay sewer pipe, for example. Chemically inert and capable of lasting centuries — only the joints needed improvement. Laboriously made in the ditch under bad working conditions, they lacked the permanence of the pipe itself, and suffered from the punishment of corrosive chemicals, roots, rodents and underground shifts.

With the advent of vinyl dispersions and CHEM-O-SOL, the entire industry took a giant step forward. Molded in place *at the factory* CHEM-O-SOL gaskets conform exactly to the uniform shape of the mold and compensate for out-of-roundness in the pipe — a condition that makes conventional gaskets infeasible. The result is a pressure-tight but flexible compression coupling adhered forever to the pipe by a specially formulated NELCO* primer.

Now contractors join pipe lengths simply by sleeving them together. Clay pipe producers, contractors, municipalities and homeowners all profit from this modern pipe that provides better sanitation and cuts costs.

Hundreds of significant product improvements like this one are possible with our versatile CHEM-O-SOL coating, molding and gasketing material. Our research facilities can turn ideas into realities — our application methods plant shortens the time between development and production.

Look ahead with CHEM-O-SOL. Write for our informative brochure. Chemical Products Corporation, King Philip Road, East Providence, R. I.

**Supplied by the Nelco® Lacquer Division of Chemical Products Corporation*

CP **CHEM-O-SOL®** THE MOST ADAPTABLE PLASTIC

READER TO EDITOR

Better boat design?

To the Editor:

I read John Beinert's interesting article about the New York Motor Boat Show boat designs (Feb 6, p 21) and would like to point out something about the new Flying Scott boat and motor combination. Mr Beinert mentioned the 15-in. transom cut out on the Flying Scott and said it retained too little freeboard. What he failed to note was that the self-bailing well is sealed and the openings for control cables, electric connections, fuel line and steering are much higher than openings on other make 20-in. transom boats. In addition to this, they are also sealed—very safe, we feel.

In regard to "cranking back windshield, then opening a deck hatch" on the Flying Scott, it does take a moment but it surely beats climbing over the windshield or up through an ordinary small hatch, don't you agree?

—R H Seeler
McCulloch Corp
Scott Div

• Reader Seeler should recall an old seagoing term—"pooped." This describes the action of a following sea that boards the boat over the stern. Unless the boat designed by Scott is to be used only in the quietest water and it is carefully slowed down, the chances of a "pooping" are always present. Despite careful sealing of all cable leads, etc, the well will hold a certain amount of water before thoroughly draining. This added weight is a serious consideration, particularly if the following seas are steep and not too far apart. One other consideration is the chance that the well proper may not be completely sealed off and the boat when pitching at mooring will take enough aboard to start sinking to the buoyant point. I know for this is not uncommon, and I have had some experience, unfortunately, along these lines.

I hate to sound like an old lady about these matters but I cannot see what gains are made producing conditions that may be themselves hazardous simply to cover up another hazard. I have sailed and powered for almost 30 years and, each year that goes by, my respect for the limitless combinations of grief that nature can dream up increases. Add to nature's grief the inate orneriness of inanimate objects such as boat and motor, and you will find that caution in design and operation make for safer fun all around. —John D Beinert

Birth of a project

To the Editor:

After reading "Birth of a Project" which appeared in the Apr 3 issue, p 52, it became apparent that some very important points were omitted. The elements of economics and competition which are of vital concern to all companies were completely ignored. Many corporations, in the last several years, have seen profit margins slip due to rising costs and increased competition.

In this age of massive engineering,

creativity costs are becoming an ever increasing percentage of production costs. This requires an orderly system to control costs and schedules. The project system is not confined to engineering but should be a team effort involving engineering, manufacturing, quality, marketing and finance. Not one can stand by itself.

The men who have reached the managerial ranks are well aware that an effective project system is one management tool that is a must—without it any type of planning results in confusion, as outlined in "Birth of a Project."

—D D Dodd and F C Brunka
Micro Switch
Freeport, Ill

COMING EVENTS

JULY

16-21 . . . . Instrument Society of America, IFME, AIEE, IRE, 4th International Conference on Bio-Medical Electronics & 14th Conference on Electronic Techniques in Medicine & Biology, Waldorf-Astoria Hotel, NYC

18-20 . . . . Western Plant Maintenance and Engineering Conference and Show, Pan Pacific Auditorium, Los Angeles

AUGUST

22-25 . . . . Institute of Radio Engineers, WESCON Electronic Show & Convention, The Cow Palace, San Francisco

23-25 . . . . American Institute of Electrical Engineers, Pacific General Meeting, Salt Lake City, Utah

28-Sep 1 . . . . American Society of Mechanical Engineers and American Institute of Chemical Engineers; Institute of Mechanical Engineers and Institution of Chemical Engineers (Great Britain), International Heat Transfer Conference, Univ of Colorado, Boulder

SEPTEMBER

11-14 . . . . Society of Automotive Engineers, National Farm Construction & Industrial Machinery Meeting, Milwaukee Auditorium, Milwaukee Wisc

14-15 . . . . American Society of Mechanical Engineers, AIEE and IRE, Joint Societies Engineering Management Conference, Hotel Roosevelt, NYC

20-21 . . . . Institute of Radio Engineers, AIEE and ISA, Industrial Electronics Symposium, Bradford Hotel, Boston

25-28 . . . . American Welding Society, Fall Meeting, Adolphus Hotel, Dallas, Texas

For a listing of addresses of societies and associations send 25¢ to Product Engineering Reader Service Dept, 330 W 42nd St, NY 36. Ask for brochure R 32.

-- every PALNUT® LOCK NUT is Dependably Uniform

-- in dimensions -- in spring tension
-- in assembly characteristics
-- in dependable locking action

Users of PALNUT Lock Nuts value their uniform quality as highly as they do the low price, assembly savings and unfailing locking action.

PALNUT Lock Nuts are mass-produced in huge volume at low cost on the most modern equipment. Quality is rigidly controlled by inspections at every step of production. Result: Each PALNUT assures your assemblers of precision thread fit—uniform hex shape—easy wrenching—free turning—accurate torquing, to speed up assembly and reduce rejects.

Learn how PALNUT Lock Nuts can cut your assembly costs, reduce fastening parts and assure vibration-proof tightness. Send details of your application for free samples and latest catalog.

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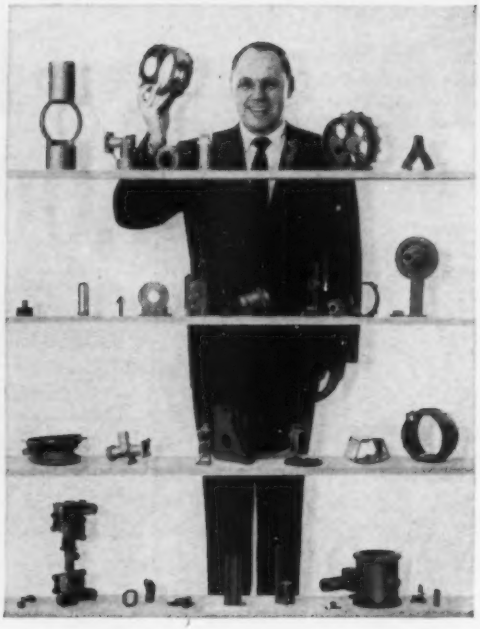
65 Glen Road, Mountainside, N. J.
Canada: P. L. Robertson Mfg. Co., Ltd., Milton, Ont.

LOCK NUTS and FASTENERS

Because we've always welcomed "little" jobs, too–

We've become the biggest in the investment casting field...



No investment casting job has ever been or ever will be too small for us.

WE DON'T HAVE ANY "SIDELINES," nor is investment casting only a sideline with us. It is the "be-all and end-all" of our economic existence.

AS A RESULT: anybody who thinks that an investment casting will help him solve a problem gets the unqualified attention of the top talent we have to offer–from our trained field engineers, our design engineers, our estimating staff, our tooling men, and our production specialists. No one of these groups cares whether your order is for 50 parts or 100,000. If they accept the order, they want it handled to or above "specs".

WHY? SIMPLY BECAUSE THESE MEN ARE DEDICATED to producing the finest that the process can deliver in any design, in any castable alloy and in quantities so small that it might surprise you.

THEIR ATTITUDE IS FAR FROM PHILANTHROPIC; they realize full well that your "little ones" may soon grow up.

ARWOOD IS READY WHEN THEY DO... more so than any other investment caster. In fact, we can take in stride all the volume that's required. Our five plants, each fully integrated, can handle the biggest job you can offer.

ONCE THE PROTOTYPE PHASE IS COMPLETED, Arwood can give you the quantity production you need, and deliver it when you need it.

WHAT MORE CAN WE SAY? Simply this. Most "difficult" components, no matter what the alloy or quantity, might well be produced as an Arwood investment casting... and THE COST IS OFTEN EXTREMELY LOW, compared with conventional methods.

ON THE OTHER HAND, IF WE CAN'T DO IT– and do it economically–we'll be the first to tell you so immediately. We'd rather lose an order than a customer. Try us and see.

ARE YOU REALLY UP-TO-DATE ON WHAT INVESTMENT CASTING CAN DO? Our 48-page "Practical Guide" gives forthright answers... tells how to design for the process, gives complete tables on properties. It's yours for the asking.

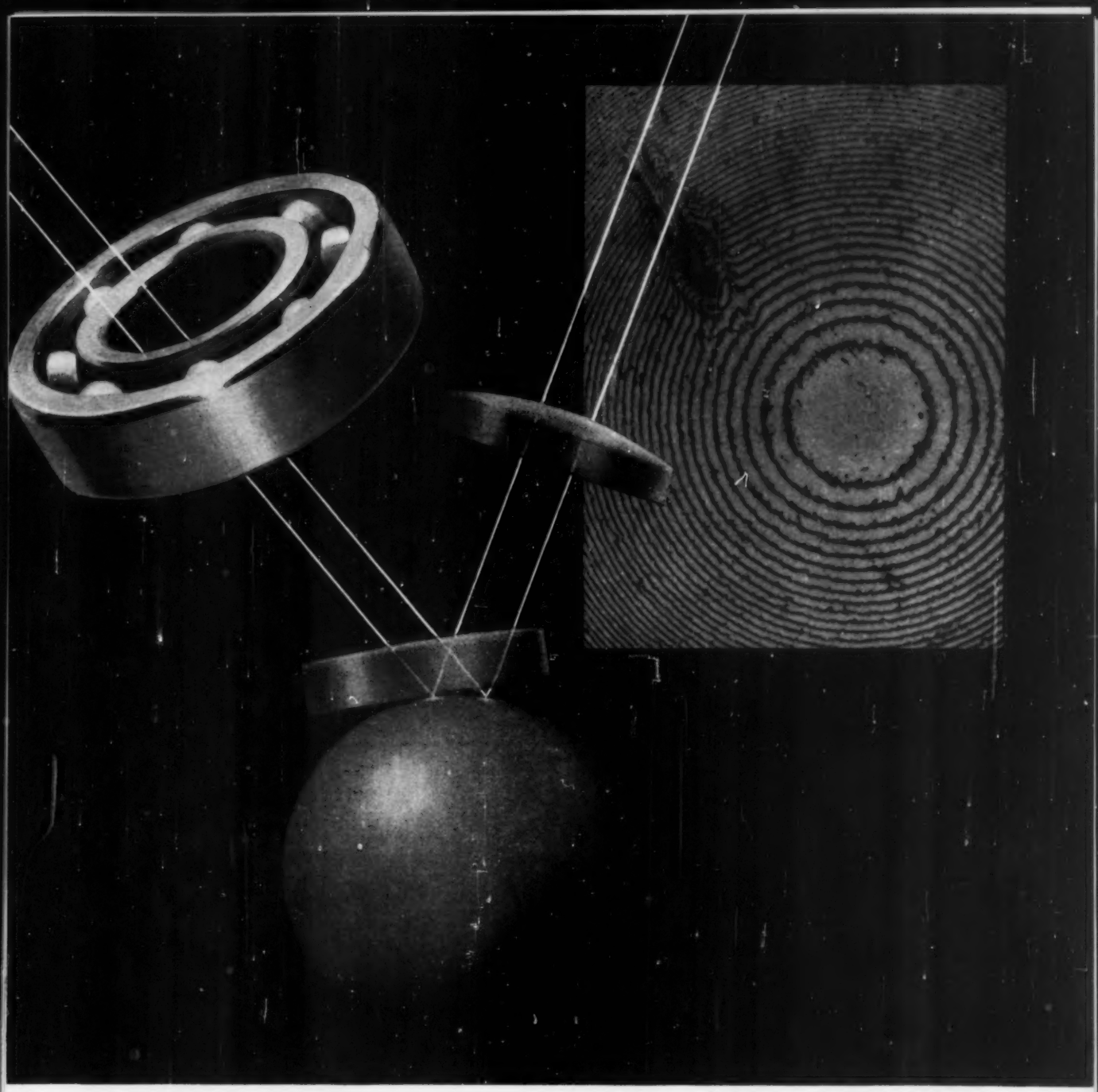
Machine the simple... cast the complex

A complete service from design through tooling, production and finish machining. Seventy-one engineering representatives from coast to coast.

arwood

ARWOOD CORPORATION • 325 West 44th Street, New York 36, New York

PLANTS IN BROOKLYN, N. Y.; TILTON, N. H.; GROTON, CONN.; LOS ANGELES AND LA VERNE, CALIF.



SPLIT LIGHT BEAMS MEASURE IN MILLIONTHS

to help SKF build better bearings

SKF MOTION ENGINEERING

Advanced ball and roller bearing technology

The concentric pattern of interference fringes in the picture above is reproduced from an actual photo taken with the aid of an interferometer in the SKF laboratories. The subject under examination is a microscopic flaw in the surface of an accurately lapped steel ball. The principle of utilizing split beams of light to form interference patterns enables accurate measurements to be made in *millionths* of an inch.

SKF is a leader in the development and application of ultra-precise measuring systems. The SKF metrology laboratory plays an important part in a continuing program of research to produce bearings of improved accuracy and finish, and consequently, quieter, smoother running characteristics.

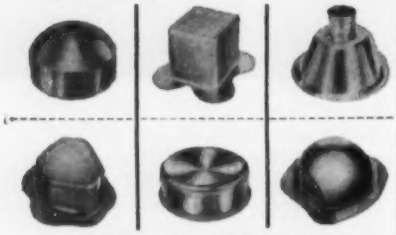
Whatever types of rolling contact bearings you need—ball, cylindrical roller, spherical roller, tapered roller or precision miniature—you'll find SKF your best assurance of dependable performance. SKF Industries Inc., Philadelphia 32, Pa. 6104

CIRCLE 31 ON READER SERVICE CARD

KAUPP
PRECISION-FORMED
METAL
COMPONENTS

Hydroforming, Deep Drawing and Spinning

You can depend on KAUPP for complete service from design to delivery on precision-made metal parts and sub-assemblies. Ultra modern metal working facilities, plus wide experience on military and commercial requirements are available to solve your problems. Send drawings for quotations or phone for new illustrated bulletins!



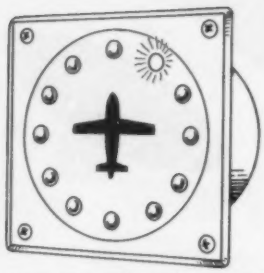
Closest tolerances adhered to in all metals, including MU METAL, BRASS, INCONEL, ALUMINUM, COPPER, CARBON STEEL, STAINLESS STEEL, NICKEL, MAGNESIUM, TITANIUM, SILVER, SPECIAL ALLOYS, HAYNES STELLITE.

C. B. KAUPP & SONS

Newark Way, Maplewood, N. J.—POplar 1-4000

METAL CRAFTSMEN
SINCE 1924

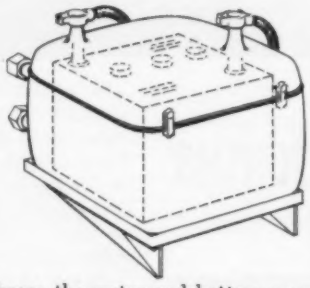
WHY DON'T THEY R&D..?



. . . an infrared proximity detector to prevent collisions between small aircraft. Could be very simple, inexpensive and easy to install. It might work something like this: All planes would carry an omnidirectional beacon that radiates visible light plus an unusually large amount of infrared (perhaps simply changing the lamp in the present beacons would be sufficient). For detection, an inexpensive infrared detector would rotate around to scan an area somewhat above and below the plane. When the detector pointed to a radiation source it would light a warning lamp under a compass rose in the approximate position of the approaching aircraft. Such a system would not be suitable for instrument flight (it does not give range or elevation) but for visual flight it should be good for several miles, day or night. —R MARIE

. . . an electric dishwasher that will accept dishes as they come from the table, without scraping or rinsing. One way is to route discharge of the washer through the waste disposer unit, thereby flushing waste down the drain. —J K KAHN

. . . a reliable automatic ignition device for the inflammable hydrogen sulfide escaping from oil wells. The gas has an unpleasant smell and to prevent contamination of the atmosphere, drilling and production regulations usually require that the gas be vented and burned after passing through a vertical riser extending 30 feet above the ground. But the ignition devices now in use are not reliable. Member companies of Canadian Petroleum Association's Alberta Division presently face this problem. They have tried several igniters but none are capable of reliably relighting the flare when it is blown out by the wind or when starting up a well that has been temporarily shut down. Mechanical and electrical igniters are quickly fouled by the corrosive action of the gas and propane pilot lights are expensive to operate and easily blown out. A satisfactory ignition device must be inexpensive, unaffected by corrosion, able to operate at temperatures down to 0 F, and independent of 110-v power.



. . . a hot-water jacket for batteries used in arctic climates. (A lead-acid battery warmed to 80 F delivers three times the power available at 0 F.) The battery container would be simply a large Dewar flask with hot water filling the space between the battery and the walls of the flask. When the engine is shut down, a valve opens allowing engine coolant to flow into the flask. The vacuum bottle arrangement keeps the water and battery warm until the next time the engine is started. Then the warm water could be pumped back into the engine to speed warm-up. —C PERKO

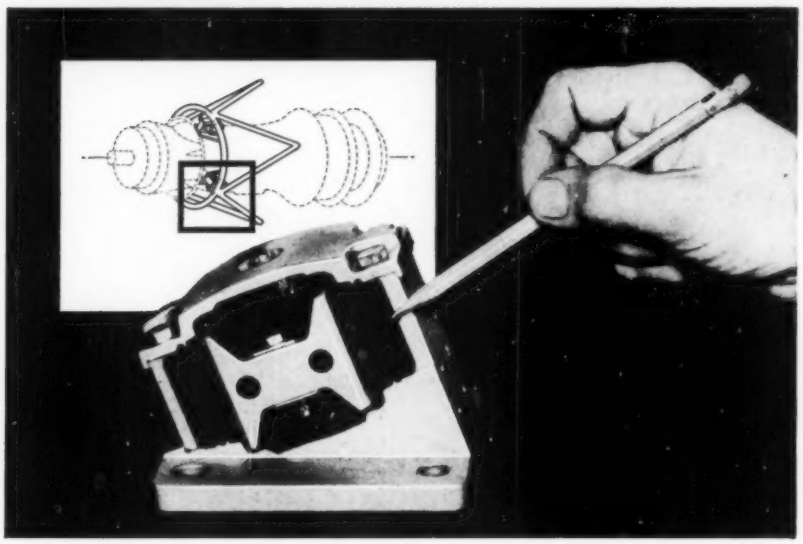
Have you a problem, based on known scientific principles, which seems to have an answer somewhere within the limits of present technology? To inspire inventors along worthwhile paths, PRODUCT ENGINEERING invites you to trade such problems with readers who have a fresh viewpoint or more time to experiment. We pay $10 on acceptance.

No. 1 in a series

VIBRATION NOTES

MB ELECTRONICS • DIVISION OF TEXTRON ELECTRONICS, INC.

Representatives in principal cities throughout the world



New MB Synthetic Coating Solves Tough Engine Mount Problem

How do you isolate the vibration of an aircraft engine when none of the available engine mount materials can meet the specifications required? MB engineers had to solve this problem in designing mounts for the turboprop engines of the Grumman Mohawk observation plane. They did it by "manufacturing" a new isolation material... natural rubber covered with a thin film of Iso-Kote, a unique elastomeric coating.

Vibration isolators for the turboprop engine had to withstand high gyroscopic loads; were limited in size by dimensions of engine mounting pad and nacelle structure; and had to be resistant to di-ester lubricant, Turbo Oil #15. Mechanical requirements left no room for compromise. Only natural rubber could meet the rigid specifications of strength, weight, space limitations and low temperature flexibility.

However, natural rubber deteriorates upon exposure for any length of time to the di-ester Turbo Oil. So, unfortunately, do those synthetics generally considered for vibration isolation.

The application of a thin coating of Iso-Kote to natural rubber provided complete resistance against the corrosion and degradation effects of the di-ester lubricant. The coating has excellent adherence and, of particular importance in vibration applications, has the same elongation as natural rubber.

The successful development of this unique engine mount material, combining the mechanical properties of natural rubber and the chemical properties of Iso-Kote, represents another MB achievement in vibration engineering.

MB engineers will be glad to assist you in solving your vibration problems. Send today for our Vibration Mount Catalog. Write to Isomode Division, MB Electronics, P.O. Box 1825, New Haven 8, Conn.

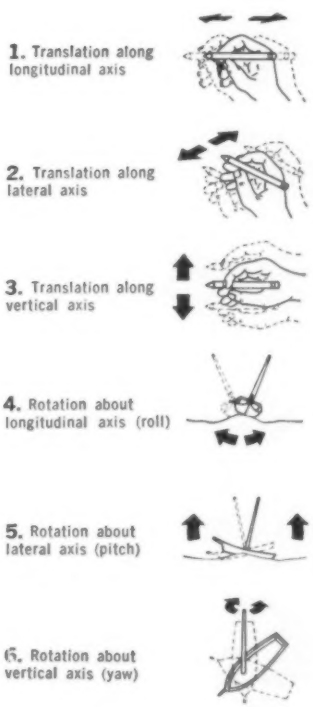
Fundamental Motions of Vibrating Bodies

Isomode is the registered trademark of MB's regular line of vibration mounts. The name is derived from the word "isolation" and from the six "modes" of motion to which all rigid bodies are subject.

In actual practice, vibration is seldom confined to a simple, single motion. If it were, control would become a fairly simple matter. But even a rigid body has six degrees of freedom in space as illustrated here.

Complex structures have even more modes of motion. These may involve the relative motion of various rigid bodies or distortion of flexible bodies.

In general, vibration problems lie in the six fundamental motions. Any of these modes may be excited by vibratory forces. To design successful vibration control, you must consider all modes and the excitations to be expected.


1. Translation along longitudinal axis
2. Translation along lateral axis
3. Translation along vertical axis
4. Rotation about longitudinal axis (roll)
5. Rotation about lateral axis (pitch)
6. Rotation about vertical axis (yaw)

CIRCLE 33 ON READER SERVICE CARD

Post-Forming: New Way to Bigger Savings with Malleable Castings

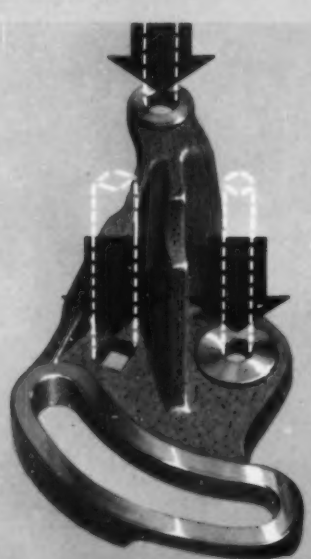
The ductility of Malleable iron castings permits use of high-speed forming techniques to finish Malleable parts at lower cost. Take advantage of the versatility you get only with ferritic and pearlitic Malleable castings. For a fuller understanding of how Malleable can help you, call any producer that displays this symbol —

Free Folder describing these techniques is available for your use. Just ask any member of the Malleable Castings Council for Data Unit No. 116, or write to Malleable Castings Council, Union Commerce Building, Cleveland 14, Ohio.

MEMBER
MALLEABLE
CASTINGS COUNCIL

Hot Form It — Hot coining this Malleable transmission part reduces finished cost . . . eliminates three cutting operations required by the previously used steel part.

Roll It — Oil grooves in lawnmower crankshafts and splines in compressor crankshafts are just two of many places where rolling proves more economical than machining.



Punch It — Holes with diameters greater than the thickness of the metal can be punched in Malleable. Two round holes and a square hole are punched simultaneously in this idler arm.

Spin It — Malleable's ductility permits the sleeve and end disc in this ball joint to be held in place by spinning the Malleable housing into a strong, permanent flange.

Get the most for your metals dollar...get MALLEABLE

CONNECTICUT
Connecticut Mall. Castings Co., New Haven 6
Eastern Malleable Iron Co., Naugatuck

DELAWARE
Eastern Malleable Iron Co., Wilmington 99

ILLINOIS
Central Fdry. Div., Gen. Motors, Danville
Chicago Malleable Castings Co., Chicago 43
Moline Iron Works, Moline
Moline Malleable Iron Co., St. Charles
National Mall. and Steel Castings Co., Cicero 50
Peoria Malleable Castings Co., Peoria 1
Wagner Castings Company, Decatur

INDIANA
Albion Malleable Iron Company, Muncie Division, Muncie
Link-Belt Company, Indianapolis 6
National Mall. & Steel Castings Co., Indianapolis 22

IOWA
Iowa Malleable Iron Co., Fairfield

MASSACHUSETTS
Belcher Malleable Iron Co., Easton

MICHIGAN
Albion Malleable Iron Co., Albion
Auto Specialties Mfg. Co., Saint Joseph
Cadillac Malleable Iron Co., Cadillac
Central Fdry. Div., Gen. Motors, Saginaw

MINNESOTA
Northern Malleable Iron Co., St. Paul 6

MISSISSIPPI
Mississippi Malleable Iron Co., Meridian

NEW HAMPSHIRE
Laconia Malleable Iron Co., Laconia

NEW YORK
Acme Steel & Mall. Iron Works, Buffalo 7
Frazer & Jones Company Division Eastern Malleable Iron Co., Solvay
Oriskany Malleable Iron Co., Inc., Oriskany
Westmoreland Mall. Iron Co., Westmoreland

OHIO
American Malleable Castings Co., Marion
Central Fdry. Div., Gen. Motors, Defiance
Dayton Mall. Iron Co., Ironton Div., Ironton
Dayton Mall. Iron Co., Ohio Mall. Div., Columbus 16
National Mall. and Steel Castings Co., Cleveland 6

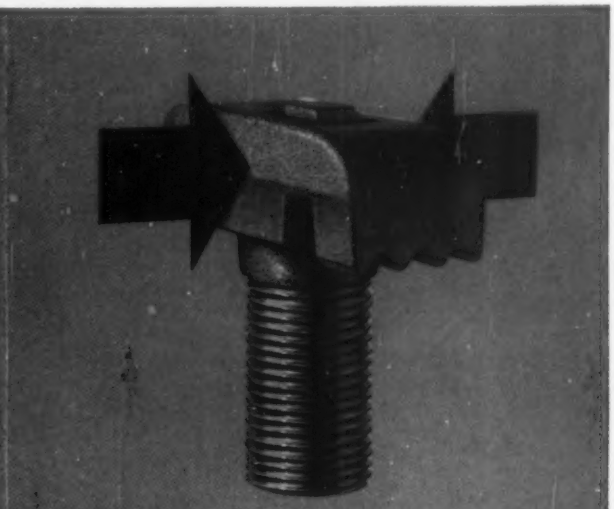
PENNSYLVANIA
Buck Iron Company, Inc., Philadelphia 22
Erie Malleable Iron Co., Erie
Lancaster Malleable Castings Co., Lancaster
Lehigh Foundries Company, Easton
Meadville Malleable Iron Co., Meadville
Pennsylvania Malleable Iron Corp., Lancaster

TEXAS
Texas Foundries, Inc., Lufkin

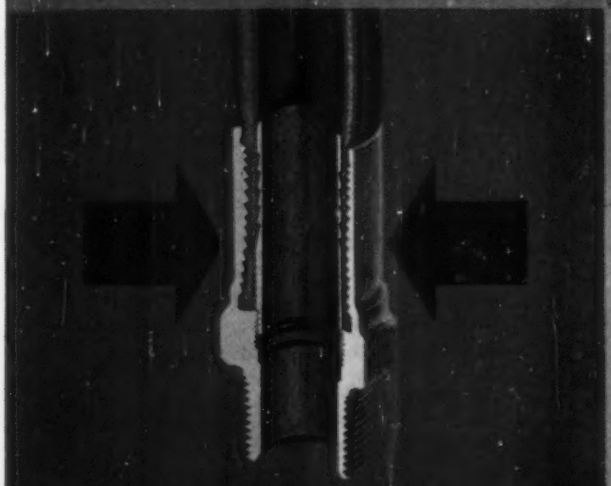
WEST VIRGINIA
West Virginia Mall. Iron Co., Point Pleasant

WISCONSIN
Belle City Malleable Iron Co., Racine
Chain Belt Company, Milwaukee 1
Federal Malleable Company, Inc., West Allis 14
Kirsh Foundry Inc., Beaver Dam
Lakeside Malleable Castings Co., Racine
Milwaukee Malleable & Grey Iron Works, Milwaukee 46

Bend It — A 30% cost reduction was achieved by casting this Malleable iron twine finger flat . . . then bending the arm about 45 degrees and coining the center hub in one fast, post-forming operation.



Coin It — Very close tolerances are often met economically by either cold or hot coining. The head of this T-bolt is coined to meet tolerances of ± .005" on its .475" width without any machining.



Stage It — Long trouble-free service is built into this high-pressure hose coupling by swaging the Malleable fitting around the reinforced hose in a 15-ton press. It's fast, permanent and economical. Working pressure of the hose is 2,000 psi.

Harden It — Surface hardness values in excess of 55 Rockwell C can be achieved with pearlitic Malleable by either flame or induction hardening. Response is excellent, and results are uniform.

CIRCLE 35 ON READER SERVICE CARD

1000 INCH-LBS. TORQUE THAT SMALL ?

You can use these new Globe planetary gearmotors to replace units 5 to 10 times as large and heavy. They slash pounds of dead weight from your design—give you up to 500 inch-pounds continuous duty or 1000 inch-pounds intermittent duty torque. Here's enough brawn to handle aircraft, missile and other high-quality, high-reliability jobs. Smaller gearbox shown above gives 200 in.-lbs. intermittent, 100 in.-lbs. continuous duty.

Globe's brand new planetary gearing system provides 22 ratios from 1.87:1 to 5211:1. Stage efficiency of **90% or better** has been achieved by using heavy duty precision ball bearings on every gear and on the output shaft. Heat treated gears and hardened output shaft withstand enormous turning and bending moments. Type BD and BL gearmotors fit your application exactly, using 21 standard armature windings for 4 to 115 v.d.c. power—custom design for your application can include speed governors, brakes, and clutches. 1¾" flange gearmotor typically weighs 1½ lb.; 3" flange high-torque gearmotor weighs 4¾ lb. typ.

Let Globe engineers review your application early in the design stage. Prototypes furnished promptly. Write for Bulletin BPG. Globe Industries, Inc., 1784 Stanley Ave., Dayton 4, Ohio. Phone BAldwin 2-3741.

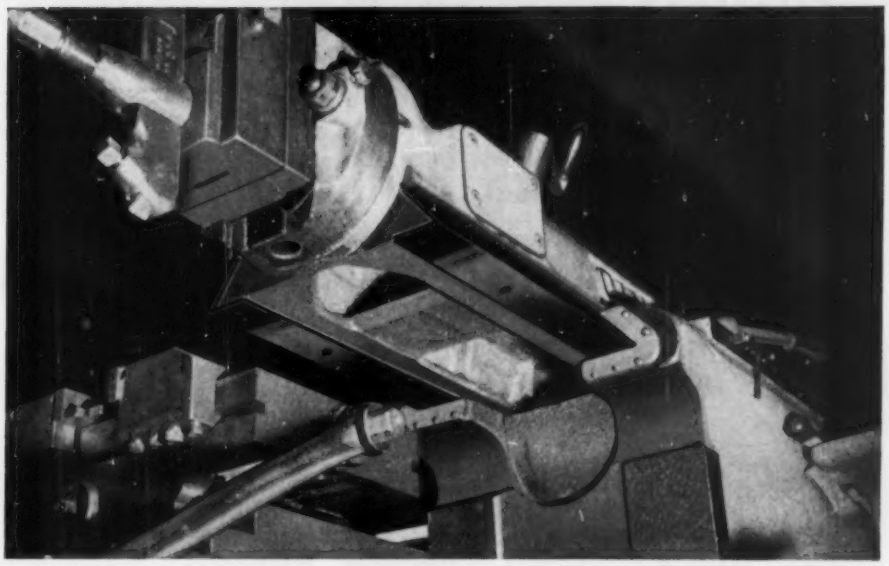
GLOBE INDUSTRIES, INC.

PRECISION MINIATURE A.C. & D.C. MOTORS. ACTUATORS. TIMERS. CLUTCHES. BLOWERS. FANS. MOTORIZED. DEVICES

GLOBE

WEAR PLATES

ANOTHER *Lamina* BRONZE-PLATED PRODUCT



Lamina bronze–plated wear plates used on shaper ways.

Lamina bronze–plated wear plates used on grinder ways.

Lamina bronze-plated wear plates and their many uses are completely described in Bulletin WP-58. Send for your free copy.

Lamina
DIES AND TOOLS, INC.
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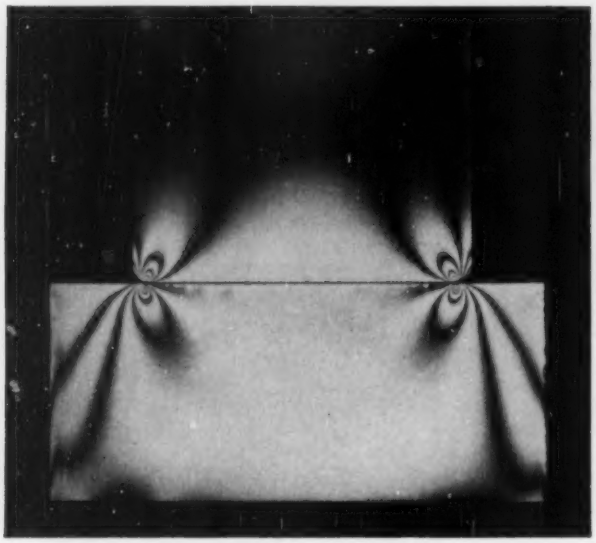
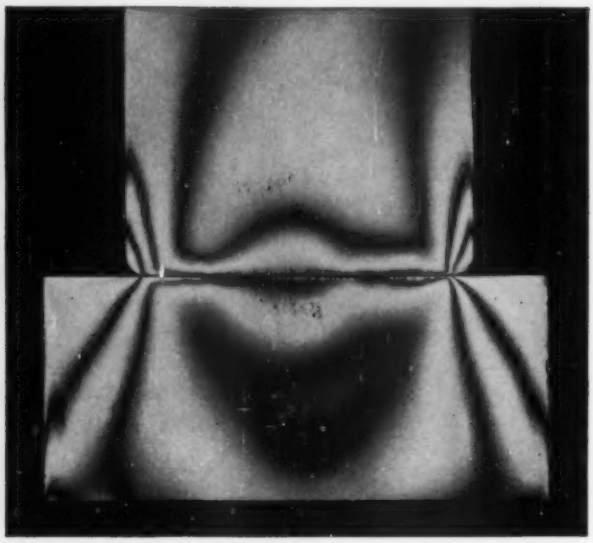
Phone: JOrdan 6-8711

One in a series of technical reports by Bower

BEARING BRIEFINGS

ROLLER BEARING LIFE AND CAPACITY LINKED TO STRESS DISTRIBUTION





These reproductions of photoelastic studies contain important evidence for every engineer and designer concerned with the performance and selection of roller bearings. In these photographs, the alternate dark and light areas, called fringes, indicate not only the magnitude of stress but also the stress distribution. The photographs were taken by Bower Research Engineers during a study of stress distribution in roller bearings.

The subjects represent rollers and raceways of two roller bearings under identical loads. The illustration at the left shows a roller of conventional design. The illustration at the right shows a Bower "Profiled" roller. That is, the roller is precision ground with a large radius generated along the body of the roller—a predetermined and controlled distance from each end.

The conventional roller photo (left) clearly shows how, under load, stress concentration builds up in and near the roller ends. This is called edge-loading. Such areas of concentrated stress are the breeding grounds for metal fatigue and eventual bearing failure.

In the photo of the "Profiled" roller (right) stress lines can be seen uniformly distributed across the whole length of the roller and raceway. There are no points of excessive stress concentration, consequently no starting points for early fatigue. Such a "Profiled" roller exhibits a great advantage in improved load carrying capacity, a most important bearing requirement.

Under actual operating conditions, Bower "Profiled" roller bearings show a considerably longer life at higher speeds and under greater loads than conventional roller bearings.

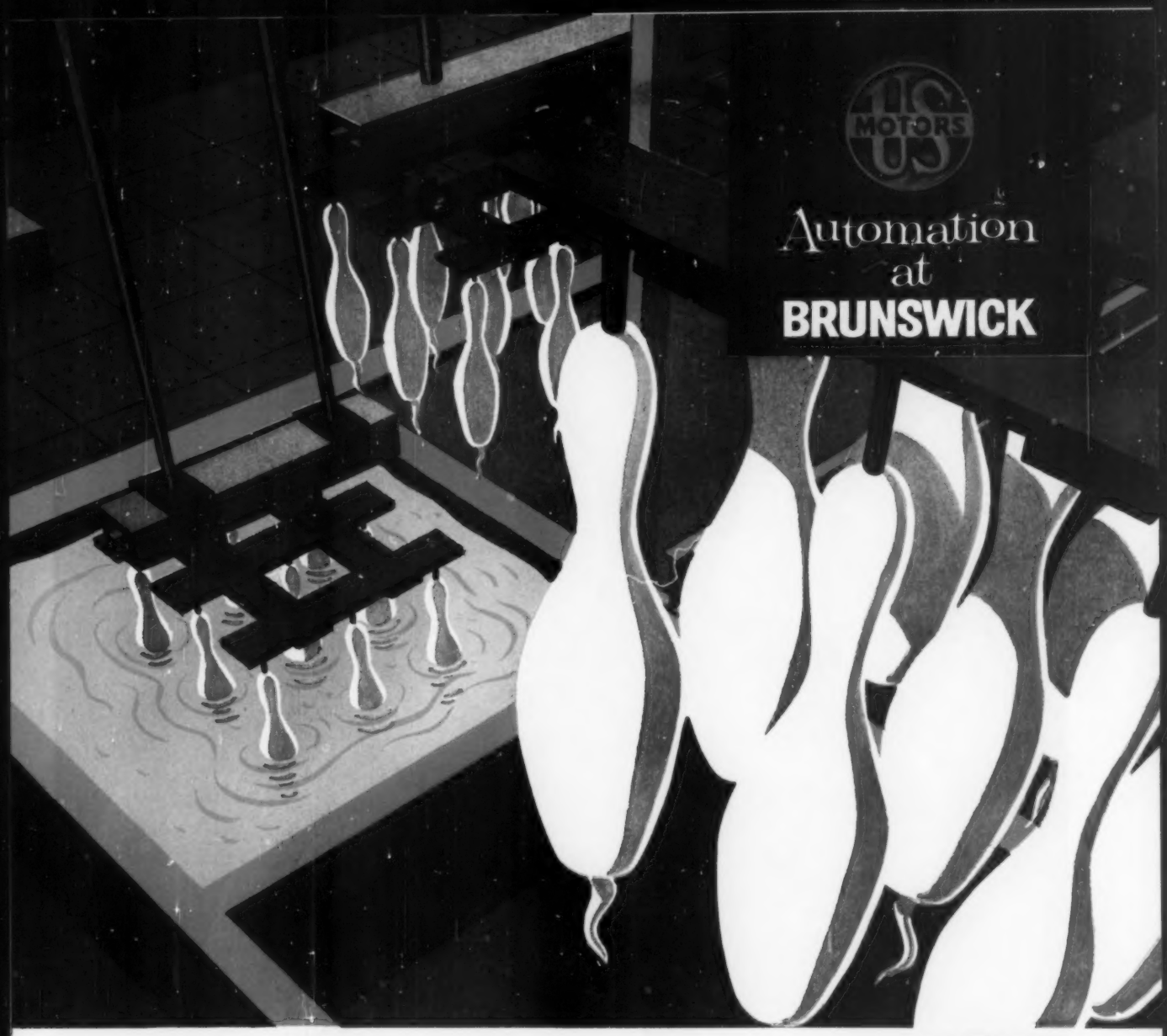
Because of this, and of other Bower features to be discussed in later technical reports, we suggest that you consider the advantages of Bower bearings in satisfying your future bearing requirements.

★ ★ ★ ★

Bower engineers are always available, should you desire assistance or advice on bearing problems. Where product design calls for tapered roller bearings or journal roller assemblies, Bower makes these also in a full range of types and sizes.

BOWER ROLLER BEARINGS

BOWER ROLLER BEARING DIVISION — FEDERAL-MOGUL-BOWER BEARINGS, INC., DETROIT 14, MICHIGAN



U.S. VARIDYNE system synchronizes conveyors for point-to-point pin transfer

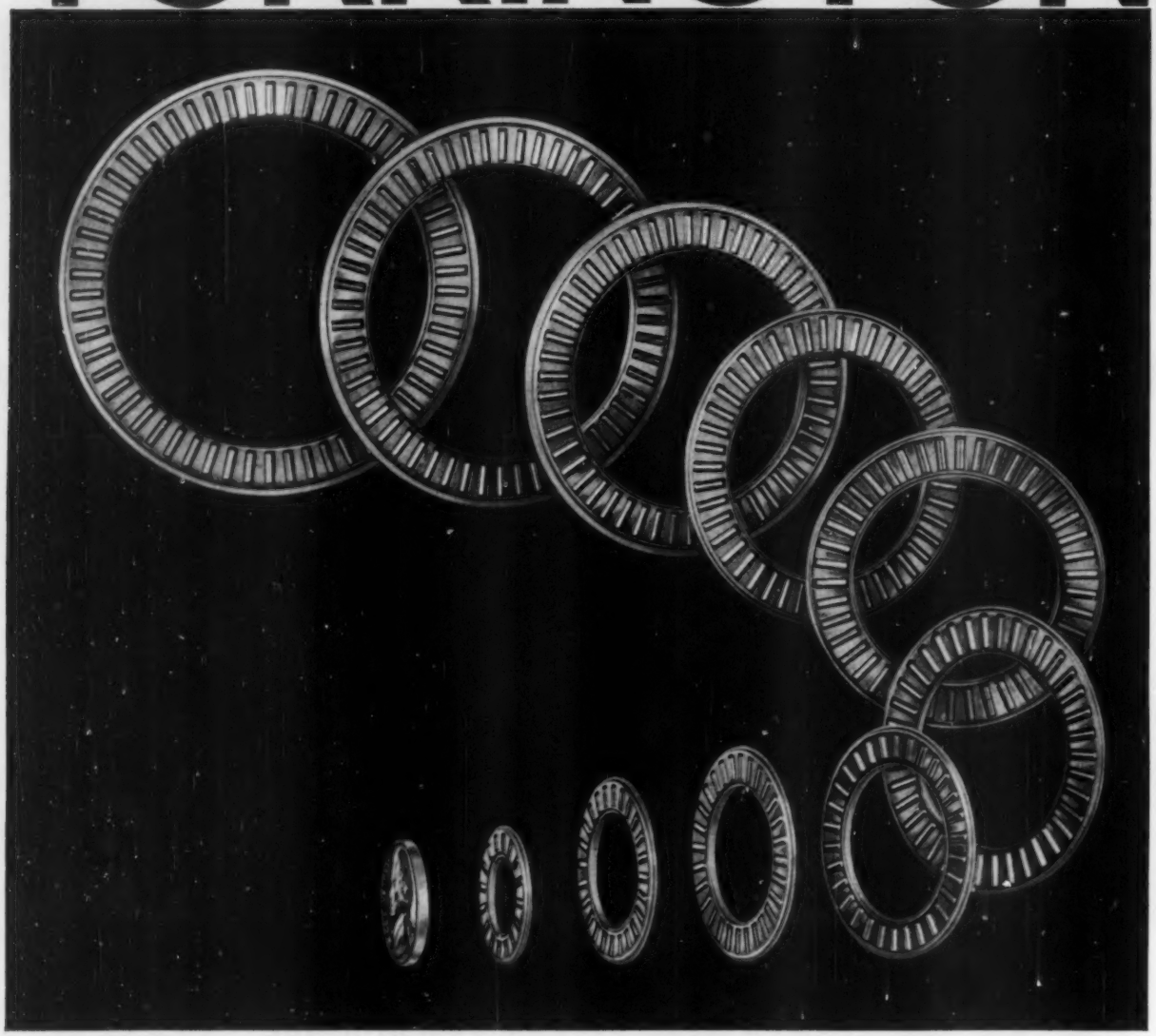
Problem: Brunswick's "Dura-King" pin required multiple dips in liquid plastic to achieve its high impact-resistant plastic coating. Resultant highly explosive atmospheres required *explosion-proof* production methods. In addition, accurate synchronization for point to point transfer between *five* variable speed, multimotor conveyors was required. **Solution:** U.S. VARIDYNE a/c Drive System with *Coordinated Start and Stop Control,* and U.S. Explosion-Proof A.C. Motors. Richards-Wilcox engineers, working with Brunswick Corp. engineers and U.S. MOTORS field engineers, chose VARIDYNE over a d.c. system because: initial start-up is simplified; instantly synchronous without warm-up; needs no synchronizing readjustments; there is no cumulative error; and *explosion-proof a.c. motors* can be used. VARIDYNE varies the frequency of a.c. current to these motors, converting them to adjustable speeds...automatically coordinated. *Write today for* VARIDYNE *Brochure F-1963.*

U.S. ELECTRICAL MOTORS INC.

P. O. Box 2058 • Los Angeles 54, California or Milford, Conn.

CIRCLE 39 ON READER SERVICE CARD

TORRINGTON



SEE WHAT YOU GET IN A BEARING NO THICKER THAN A NICKEL

Torrington Needle Thrust Bearings offer true anti-friction operation, high thrust capacity, wide size range, low unit cost...all in a unit no thicker than a nickel or ordinary thrust washer.

That's not all! These exceptional bearings have an O.D. much smaller for a given shaft size than any other type of thrust bearing. You can run them on hardened and ground surfaces, or on standard races. They're completely self-contained . . . can be easily handled and installed.

Remember Torrington Needle Thrust Bearings next time you need better performance in a restricted space. Call or write us for more information.

RACES IF YOU WANT THEM
Standard races are available. Otherwise Torrington Needle Thrust Bearings may be run directly on hardened and ground adjacent surfaces.

progress through precision

THE TORRINGTON COMPANY

TORRINGTON BEARINGS

Torrington, Connecticut • South Bend 21, Indiana

The Bellows Air Motor®
Makes Pneumatic Circuits
Easier to Design • Easier to Build

The Bellows Air Motor makes designing for air operation a lot easier and less costly. Its built-in directional valve, built-in speed controls, and its single air connection (which can be flexible hose) is true space-saving design—makes it fit perfectly in cramped quarters or on moving machine elements. And from the standpoint of final design, the Bellows Air Motor offers faster action, more positive control, and minimum maintenance.

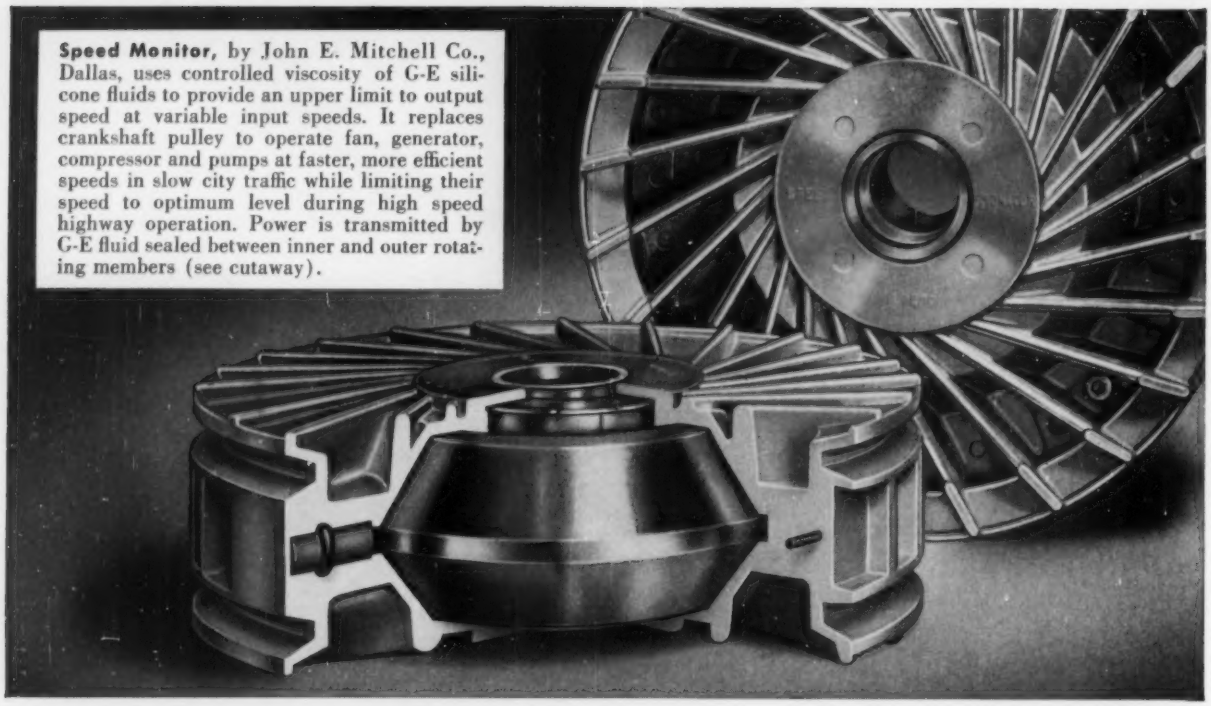
The Bellows Air Motor is available in various mounting styles, in five bore sizes (1¼", 1¾", 2½", 3⅝" and 4½"), and in any stroke length. Optional built-in valves include 8-12v low voltage control, 115v JIC electric control, manual or pneumatic controls, thus giving the design engineer the widest latitude in control systems.

Full data on Bellows Air Motors is in Bulletin BM-25, free on request. Write Dept. PE-761, Bellows-Valvair, Akron 9, Ohio.

Bellows-Valvair
AKRON 9, OHIO
DIVISION OF INTERNATIONAL BASIC ECONOMY CORPORATION (IBEC)

996-C

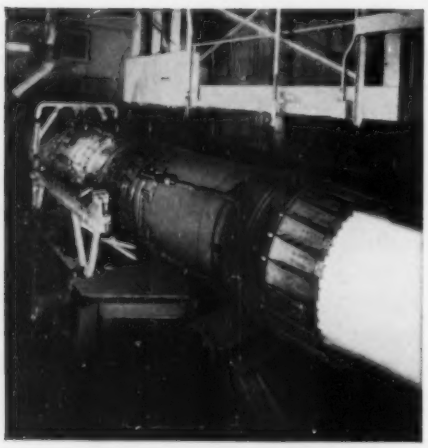
CIRCLE 41 ON READER SERVICE CARD

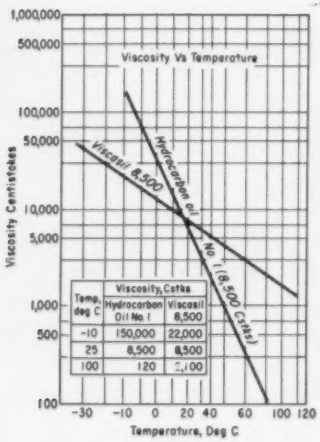


Speed Monitor, by John E. Mitchell Co., Dallas, uses controlled viscosity of G-E silicone fluids to provide an upper limit to output speed at variable input speeds. It replaces crankshaft pulley to operate fan, generator, compressor and pumps at faster, more efficient speeds in slow city traffic while limiting their speed to optimum level during high speed highway operation. Power is transmitted by G-E fluid sealed between inner and outer rotating members (see cutaway).

GENERAL ELECTRIC SILICONE FLUIDS

for reliable performance under tough operating conditions





Temp. deg C	Viscosity, Cstks Hydrocarbon Oil No. 1	Viscasil 8,500
-10	150,000	22,000
25	8,500	8,500
100	120	2,100

Thermal stability. The outstanding thermal and oxidative stability of G-E silicone fluids, over an operating temperature range of −100°F to 600°F, makes them suitable for such rigorous applications as jet engine lubricants and aircraft hydraulic fluids. G-E Versilube fluids give unequalled performance at high temperatures and are comparable to other hydraulic fluids in moderate ranges.

Nearly constant viscosity over wide temperature range. G-E silicone fluids exhibit very small changes in viscosity with wide temperature variations. This makes them ideal for many mechanical applications, including fluid drives, dash pots, vibration dampers, timers, shock absorbers, or wherever constant viscosity is needed.

Get the complete story. These bulletins give complete technical data on the G-E silicone fluid line and describe many of the ways in which designers are taking advantage of their outstanding properties. For your free copies, write to Department A753, General Electric Company, Silicone Products Department, Waterford, N. Y.

GENERAL ELECTRIC

CIRCLE 43 ON READER SERVICE CARD→

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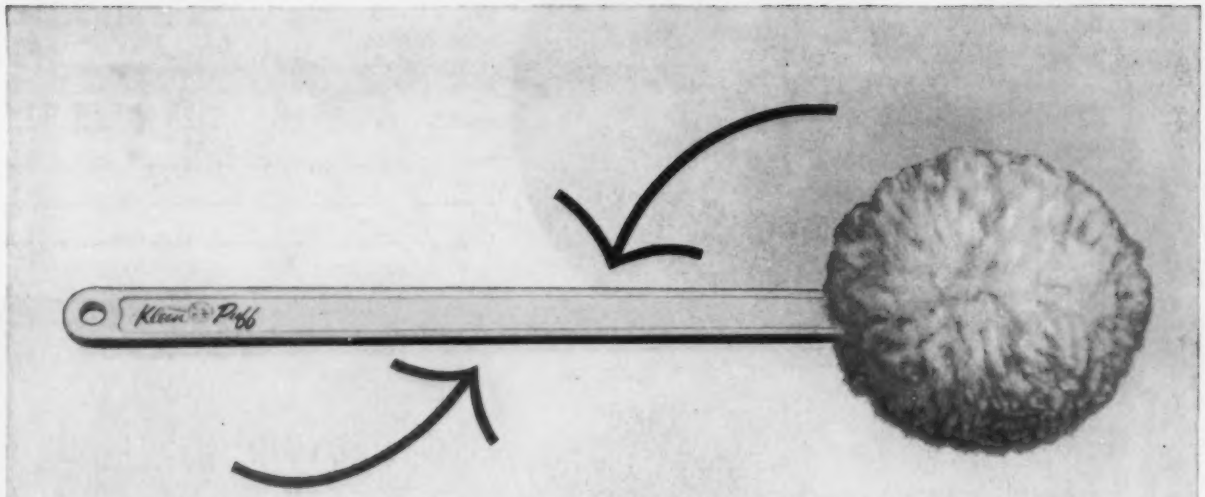

CMPC-molded mop handle has built-in germ fighter

Often, engineered plastics add important extra sales features to a product. A good example is the "Kleen-Puff"® mop, manufactured and sold internationally by the Zelinkoff Company of Wichita, Kansas.

CMPC injection molds the one-piece handle using a polypropylene-bacteriostat mixture. The bacteriostat, Biozel®, inhibits the growth of bacteria and odor-causing germs and resists mildew and mold . . . a big selling plus with housewives. Biozel is non-toxic and non-irritating to the skin. Tests indicate that its effectiveness continues for a year and longer.

Polypropylene was selected for the handle because of its strength, light weight and flexibility. These properties enabled CMPC to mold a small strap, used to fasten the mop attachment, as an integral part. Thus, the handle is strong and flexible—will bend around curves without breaking and it has no sharp edges to scratch surfaces being cleaned.

Perhaps these same advantages can be applied to your product. A call to your Chicago Molded Sales Engineer will bring you the services of an experienced and trained plastics specialist. Or write:

Send for new brochure "Design and Purchase of Custom Molded Plastics."

CMPC

CHICAGO MOLDED PRODUCTS CORPORATION
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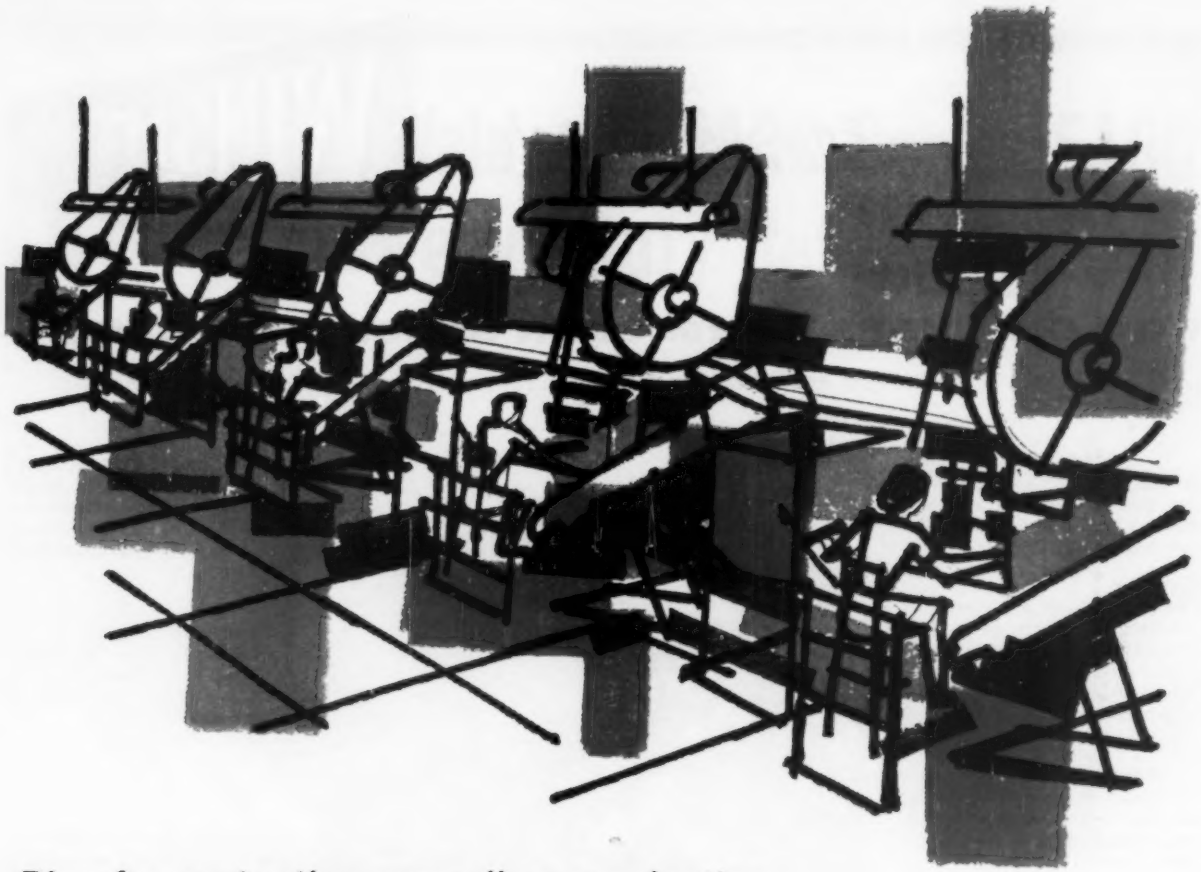

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ACCUMITE – small, easily installed system gives positive measured shot of oil or light grease to each bearing.

ACCUMATIC I – simple, single line system for oil or medium weight grease. Wide range of valve capacities.

ACCUMATIC II – twin line system can easily handle every heavy grease that can be pumped.

ALEMITE OIL-MIST – delivers air-borne oil mist to every bearing to lubricate, cool, shut out dirt and grit.

Only Alemite has all four Centralized Lubrication Systems... one of them is just right for any machine or installation you design.

Modern designs and engineering plans aren't complete without one of the four Alemite Centralized Lubrication systems. Available for *every* industrial application, Alemite Centralized Lubrication protects automatic equipment and installations – keeps performance up-to-date–helps give years of dependable service. When power-driven units are equipped with Alemite Centralized Lubrication all points that need lubrication get it – *automatically and economically.* Operating life is extended. Breakdowns and excessive wear are minimized. Accurately measured amounts of lubricant are applied to prevent waste as well as to reduce material and product spoilage.

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Dept. CC-71, 1850

CIRCLE 45 ON READER SERV ARD

Engineering Data

WINSMITH SPEED REDUCERS

HOLLOW SHAFT WORM GEAR SPEED REDUCERS

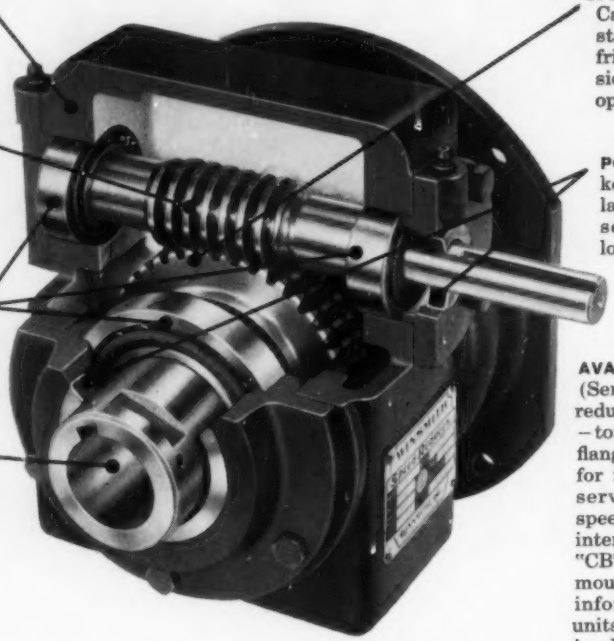
single and double reduction . . . torque arm and flange mounted models

CAST IRON HOUSINGS designed for high heat radiation. One-piece construction, close-grained gray iron for maximum strength and rigidity.

CASE-HARDENED STEEL WORMS cut integral with the shaft. Heat treated for close-grained tough core, carburized and hardened before grinding. Meet AGMA long-wear specifications.

TAPERED ROLLER BEARINGS for minimum maintenance, long bearing life and permanent shaft alignment. High radial and thrust load capacity.

HOLLOW SLOW SPEED SHAFTS in wide range of standard bore sizes and keyways. Mounts on shaft of driven machine *without bushings*—two external slots facilitate removal with standard wheel puller.



SPECIAL BRONZE WORM GEARS Cast to recommended AGMA standards. Low coefficients of friction and thermal expansion for cooler, more efficient operation.

POSITIVE OIL SEALS keep oil in, dirt out. Shafts lapped to micro-finish under seals for uniform contact, longer seal life.

AVAILABLE in single reduction (Series ST and SF) and double reduction (Series STD and SFD)—torque arm ("T" models) and flange mounted ("F" models)—for intermittent or continuous service. Hollow shaft slow speed assembly of "ST" series interchangeable with Winsmith "CB" and "CT" Series with foot mounted housings. For further information on these latter units, write Winsmith Engineering Department.

- *12 Models*
- *.041 to 8.82 H.P.*
- *Ratios 7½:1 to 4466:1*
- *Max. Output Torque 816 to 7678 in. lbs.*

Winsmith Hollow Shaft Speed Reducers cover a broad range of power transmission requirements for both single and double reduction drives. *Their worm gearing provides much higher reduction ratios than are possible in comparable size units using other types of gearing.* Winsmith Hollow Shaft models are designed for all applications where it is advantageous to mount the reducer on the shaft of the driven machine. They are compact, easy to install and require less space than conventional units. Their design and construction provide high shock load resistance; maximum thermal capacity without induced cooling; greater overhung capacity; and a high degree of standardization which eliminates excessive special application engineering.

Write today for complete information or call your nearest Winsmith Representative listed in the Yellow Pages. He is a technically trained expert who is always ready to help you with any speed reducer problem. For both standard and special power transmission applications, you'll find it pays to standardize on Winsmith.

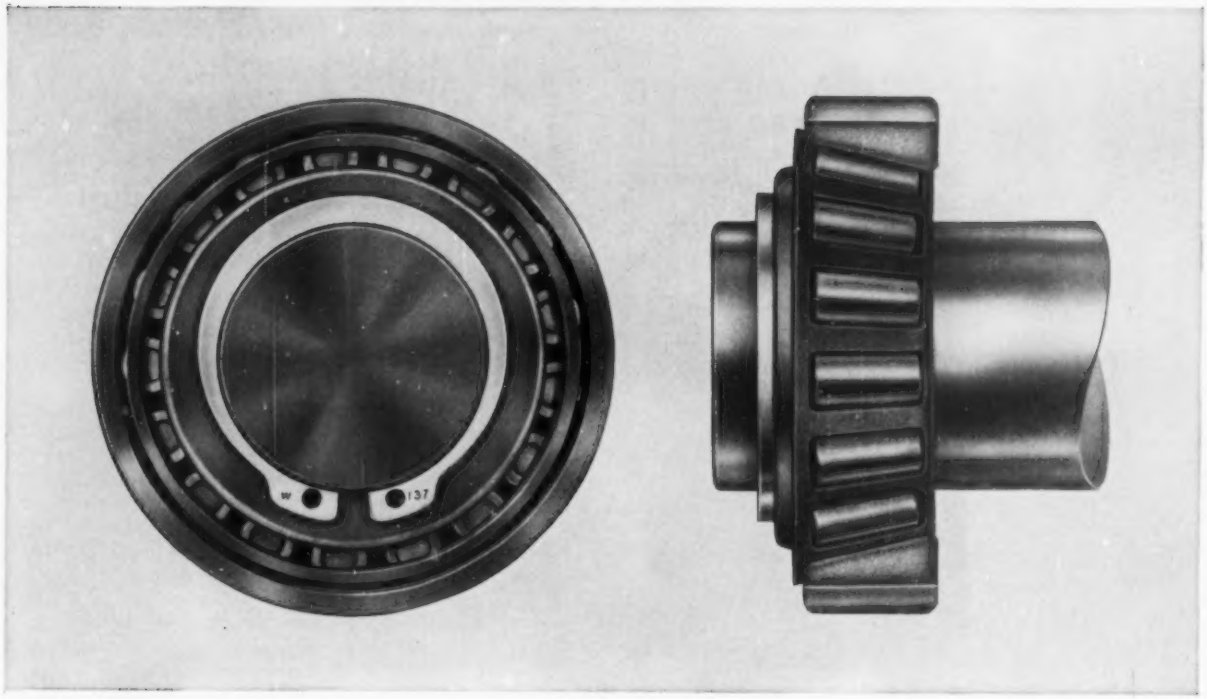
WINSMITH, INC.

208 Eaton Street, Springville, (Erie County), New York

MEMBER OF AGMA

• • • Winsmith Speed Reducers are made by American craftsmen to meet American design and production standards.

NEW! Waldes TRUARC Series 5160 Heavy-Duty Retaining Ring



for thrust and impact...for retaining bearings ...for a new approach to heavy-duty fastening

Now you can enjoy the benefits of a truly heavy-duty fastener — with all of the advantages and production economies retaining rings provide. The new Truarc Series 5160 is a unique external ring designed to secure components on shafts, axles and similar structural members. It has high thrust load and impact resistance and forms a shoulder sufficiently high to retain parts having large corner radii or chamfers. The Series 5160 is ideal for retaining bearings. You can use it *without spacer washers* to secure ball bearings, tapered roller bearings (shown above) and cylindrical roller bearings — all having large corner breakouts. The ring eliminates the need for machined shoulders, costly heavy-duty nuts and other bulkier and more expensive fastening devices normally required for extreme loading conditions. The Truarc Series 5160 is available in 11 popular sizes for shafts ranging from .473" to 2.0" dia. — and other sizes are on the way. You can order the Series 5160 in carbon spring steel or — for corrosion resistance and high temperature limits — in Armco PH 15-7 Mo stainless steel. Sizes up to 1.378" also are available in beryllium copper. For complete specifications, write for Truarc Data Bulletin No. 459-11. Better yet, contact your local Truarc Representative or Distributor. They're listed in the Classified Telephone Directory under "Retaining Rings" or "Rings, Retaining."

SEE FOR YOURSELF — Send for a free sample of the Truarc Series 5160 Heavy-Duty ring. We'll include a standard external ring of the same size for comparison. You'll see the difference as soon as you open the envelope!

WALDES KOHINOOR, INC.

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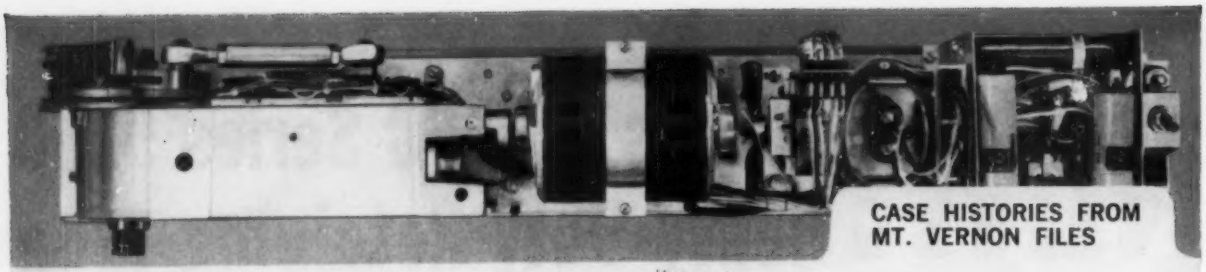
WALDES TRUARC® RETAINING RINGS



CASE HISTORIES FROM
MT. VERNON FILES

The STANLEY® MAGIC-DOOR Electric Operator . . . another open and shut case for die casting– ...MT. VERNON die casting

From Stanley* comes this new electric, automatic door opener, compact and economically priced and amply powered to handle all new or existing doors up to 42" widths — weights up to 150 lbs.

The Operator, a compact power package, measures only 5½" x 6" x 31"— weighs less than 40 lbs. — contains 5 major assemblies including a transmission which is the muscle. Although the transmission case is somewhat smaller than an ordinary shoe box, it contains all the gears, cams, bearings, linkages, etc. for converting the high speed output of the motor into a mighty and instantly responsive door-swinging thrust.

Shown here are the 5 Mt. Vernon die castings which make up the transmission case—3 cover plates—1 bridge plate and 1 main housing. Your practised eye will tell you that the latter is a very complex casting — a compact casting designed with enormous built-in strength to meet its service load strains.

Producing castings of this nature is never easy — but rarely a problem at Mt. Vernon for we offer manufacturers more than die casting production. Ours is a four-fold service • designing, die making, casting and machining • a coordinated service — all under one roof in 200,000 sq. ft. of space. The most advanced independent die casting plant in the country.

Complex or simple, why not bring your die casting problems to us. What we do for Stanley and others we can surely do for you. Just call your nearest Mt. Vernon Field Salesman or our home office.

*The Stanley Works, New Britain, Conn.

MT. VERNON DIE CASTING CORPORATION

Stamford, Connecticut

FIELD SALESMEN—BALTIMORE, MD.: Mr. C. M. Gordan, 919 St. Paul St. • **BROOKLYN, N. Y.:** Mr. Robert V. Moore, 2317 Plumb 2nd St. • **MARIETTA, N. Y.:** Mr. Burt J. Meldrum, Olanco Road • **PITTSBURGH, PA.:** Mr. Andrew W. Anderson, 300 Pasadena Drive So. • **STAMFORD, CONN.:** Mr. Anker Anderson, Cascade Road • **VALLEY FORGE, PA.:** Mr. G. T. McMaster, P. O. Box 115

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simplifies design for speed reduction economy

Helical geared Ratiomotors and Reductors – single or double reduction.
For 1/6 to 15 HP drives. Horizontal or vertical base mounted, or shaft mounted.
680 mounting combinations **from stock** – meet any in-line need.
Furnished ready to install, by local Distributors.
Specify **OPTIMOUNT.** Save extra cost of special gearhead motors.
Save design time. See Catalog 57 for complete listings.
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CIRCLE 49 ON READER SERVICE CARD

Here's Take-Your-Choice Versatility

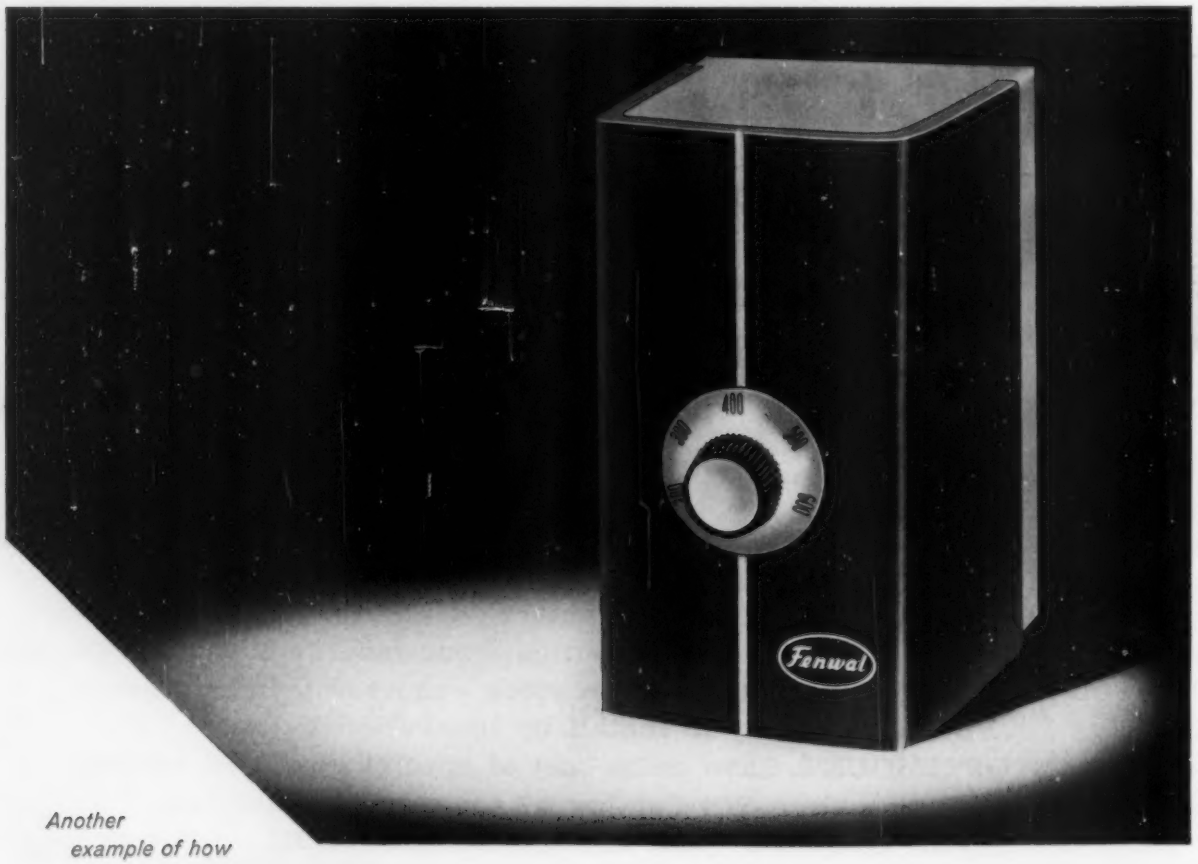
with the Multi-option Fenwal 536 Temperature Controller

It's so *precise* and yet so *easily adaptable* to an almost endless variety of temperature control applications, you become all but convinced that the transistorized Model 536 was engineered with only your needs in mind!

From its multi-option printed circuit board to its numerous interchangeable components, the Model 536 Temperature Controller spells *versatility*. ON/OFF or proportioning control . . . dial for set point adjustment mounted externally or internally . . . expanded scales for precise temperature adjustment — the 536 offers all these advantages! Five standard temperature ranges from −50 to +600°F . . . separate potentiometer with graduated dial and knob for remote temperature adjustment . . . capacity of 10 amp/110 VAC and 5 amp/230 VAC . . . these choices are also available to you. *And you pay only for the options you need!*

The 536 is sensitive to within 0.1F°. And if you wish to build a multi-point control and indication system — either gradually or all at one given time — you simply combine the Fenwal Model 580 Temperature Indicator with as many 536 Controllers as you require. Thermistor sensors enable fast response and ordinary copper lead wire may be used for connections. Removable interior of the Model 536 allows easy, safe installation and the instruments are smartly styled to perfectly complement modern industrial machines and interiors.

Find out more about how the precise Model 536 Temperature Controller can be adapted to your exact needs by writing to FENWAL INCORPORATED, 27 Pleasant St., Ashland, Mass. Request Bulletin MC-195.



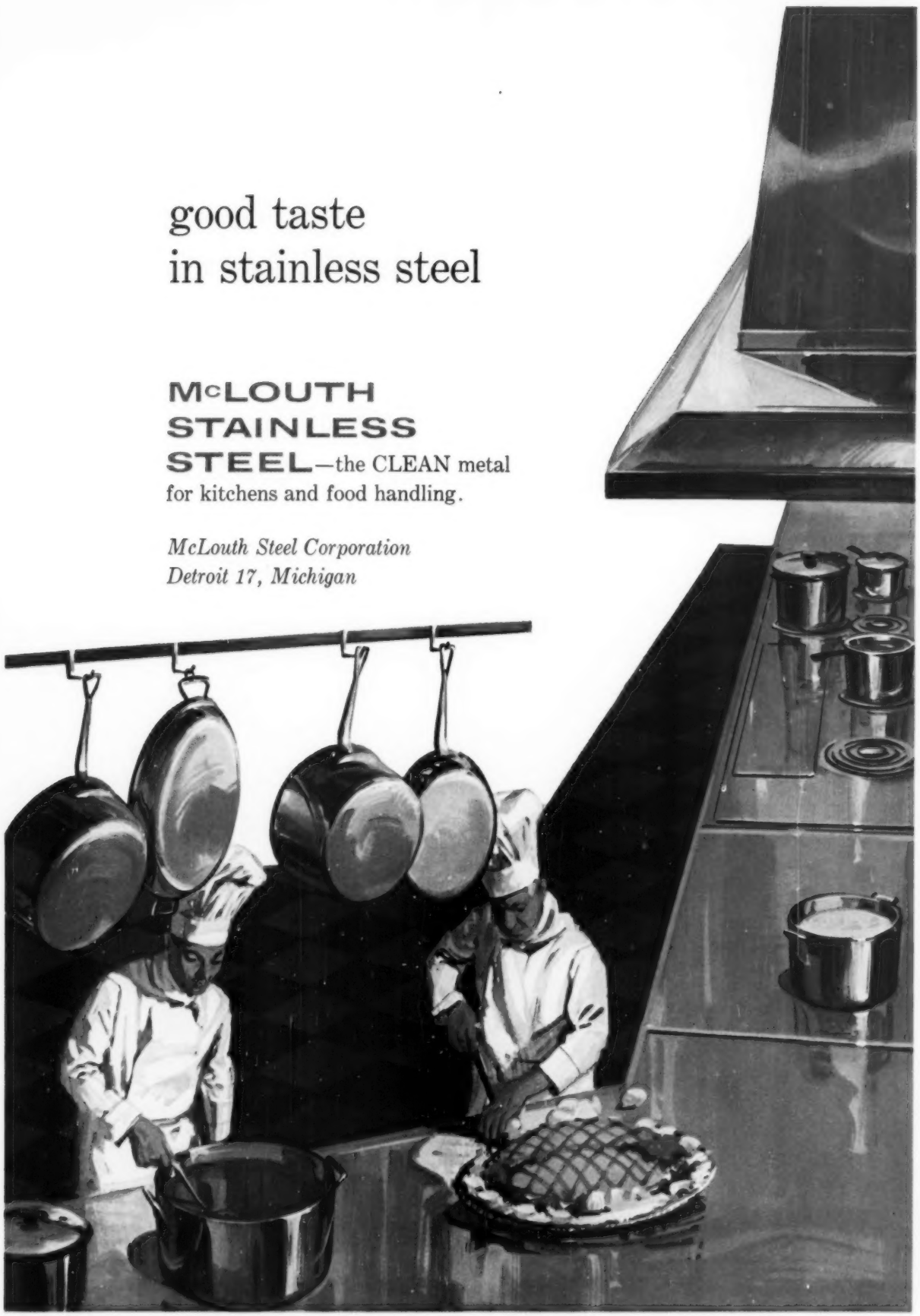
Another example of how

Fenwal CONTROLS TEMPERATURE . . . PRECISELY

good taste
in stainless steel

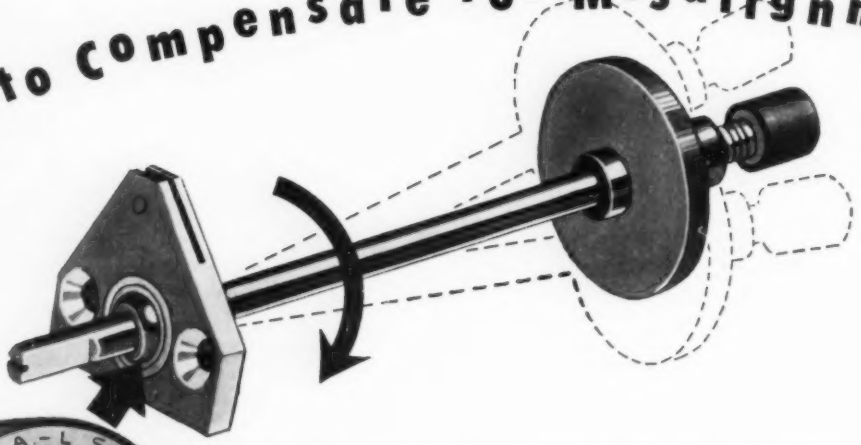
McLOUTH STAINLESS STEEL—the CLEAN metal for kitchens and food handling.

McLouth Steel Corporation
Detroit 17, Michigan



This application shows...

How to Compensate for Misalignment

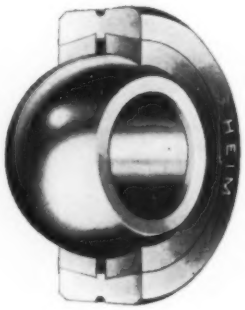


The shaft in this assembly rotates continuously in a horizontal position, and, when copy is being fed into the camera, a cam raises the shaft 5° - 10° out of alignment to bring the rubber roller at the free end of the shaft into contact with the film. This is the mechanical heart of the Diebold Portable Microfilm Camera.

At the fulcrum, is a HEIM *Unibal*® spherical bearing

This self-aligning bearing not only compensates for the inherent misalignment of the shaft, but delivers the smooth operation which prevents hesitation or binds that would show up as objectionable density bars in the picture.

The HEIM *Unibal*® SPHERICAL BEARING



represents a simple, trouble-free self-aligning bearing principle. This cutaway view shows how the single ball has universal movement, rotating in bronze bearing inserts, and presents a large surface supporting area. This permits higher load ratings to meet virtually every application requirement.

Heim Unibal Bearings are sold and stocked by the leading bearing distributors in the U.S. and Canada. Write for complete catalog and list of distributors/ or for any engineering data on special problems.

THE HEIM COMPANY

FAIRFIELD, CONNECTICUT

A SALES-BUILDING IDEA FOR YOUR PRODUCTS, TOO

This exceptional vinyl can be laminated permanently to metal for an integral finish of distinctive color and design! That's its beauty as a selling plus. And here's its beauty from a *production* standpoint: It can be cut, crimped, drilled or deep-drawn without impairing its beauty or distorting the material. No new processing equipment needed. Enables you to work with prefinished parts. Can even eliminate the need for spray booths and baking ovens. Cleans easily. Write for information and samples.

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Furniture by FALCO PRODUCTS CO., Philadelphia, Pa. Masland Duran Clad used on table. Matching upholstery grade Masland Duran on chair.

Bearing at left has 1.75" bore, while tandem bearing in main illustration has 17.0" bore. *Yet both are standard, cataloged items.*

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When you need a thrust bearing, no matter how special, Rollway is ready with the know-how and the precision machinery to design and produce it for you.

Our engineers will gladly consult with you regarding any standard or special-purpose types you need. No cost. No obligation. Rollway Bearing Co., Inc., Syracuse. N. Y.

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PRODUCT ENGINEERING HORIZONS

July 10, 1961

The Sand Witch Tragedy

(From the report of an African Expedition in 6061 AD)

Our expedition to the Great Continent to the West has made an important and confusing discovery that seems to explain what happened to the civilization there. Scholars have succeeded in translating certain fragments found in the Bruklyn Mound.

Contrary to our previous deductions that the words "sand witch" described a sort of tribal god or earth deity, it now seems that something entirely different was meant. There is apparently some relationship between "sand witch" or "sandwich," as it is more commonly spelled, and "hot dog," "frankfurter," "hamburger," "hero" and "submarine," because all occur together repeatedly. The language of these lost people of the salt desert is abundant with examples of such multiple use of descriptive terms.

Research seems to show "sandwich" is some sort of foodstuff, although at least one fragment shows it in connection with the words "chicken club"—which other fragments indicate was some sort of weapon carried by unmarried girls.

However, a newly discovered scroll speaks of a form of sandwich hitherto undiscovered, seemingly a combination of factory owners or managers on one side, working men on the other, with something called "engineering" between. We have no equivalent to "engineering," which seems to have been concerned with devices strange to us and made of materials of which only traces remain. It also dealt with power, a purported way of multiplying human energy (although it is described in terms of horses) which we are unable to do. We hope that further digging in the Snekteddy Mound will provide some explanation for this and for the obvious folk tales of this people dealing with visits to other earths. There seems also to be some connection between these folk tales and the indications that this tribe vanished in a holocaust.

In any case this great tribe appears to have been divided into three arbitrary subdivisions. The "factory," according to the fragments, was a communal working place, with some of its people classified as "labor," who were like our workers. They were continually at odds with another group called "management," which operated its factories and wore white collars as badges.

According to the new scroll, there were originally only workers and management. Then the central portion, engineering, was added to create a sandwich (although this was apparently inedible). Engineering grew quickly and soon dominated the sandwich. The other two elements became correspondingly less important—until they took up arms to force a drastic reversal of the trend.

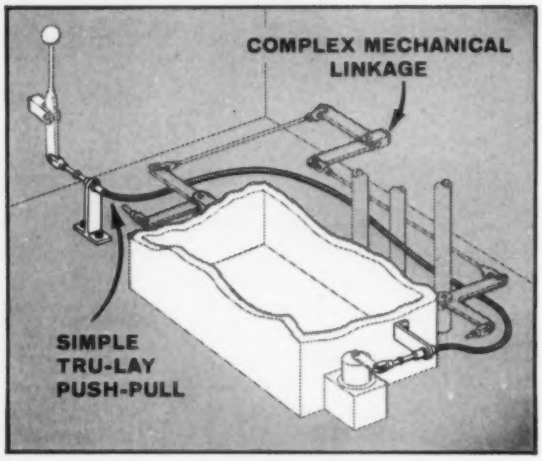
Thus the sandwich lost its central section. The scroll ends with the cryptic statement: "With the filling gone, the sandwich wouldn't cell." Obviously, this is a reference to the problems of propagating the race by fission (cell division) which, uncontrolled, destroyed the tribe.

K. F. Tangeman

ACCURATE REMOTE CONTROL FOR HUNDREDS OF PRODUCTS

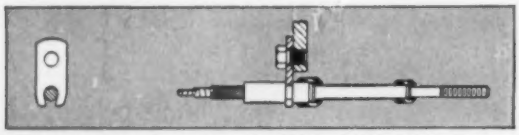
— — with Tru-Lay *PUSH*-PULL Controls

If your products involve remote control—electrical, hydraulic, pneumatic or direct—TRU-LAY PUSH-PULL FLEXIBLE CONTROLS can help solve your design problems. They provide positive remote control over short or long distances—up to 150 feet from the control point. Because they operate while flexing, they can snake around obstructions. They will not buckle. They are ruggedly constructed, easily installed and operated, sealed against dirt and moisture, and will handle jobs with as much as 1,000 lbs. input. PUSH-PULL CONTROLS are simple, have but one moving part, are noiseless and give a lifetime of accuracy. Mechanical linkages, on the other hand, are complex. Unlike PUSH-PULL CONTROLS, they are made of many parts, wear at many points, and produce increased backlash, vibration rattles and lost accuracy.

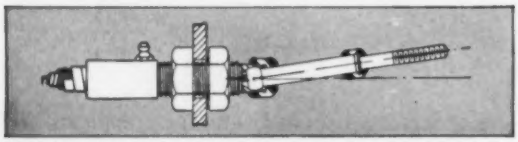


THESE FEATURES HELP SOLVE DESIGN PROBLEMS

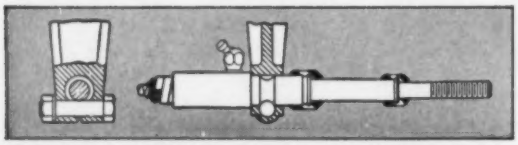
Anchorages



Clip anchorage • a simple clip for light loads

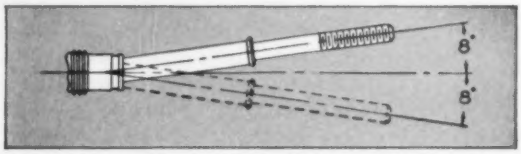


Bulkhead anchorage • for heavy-duty installations



Machined bracket anchorage • can be furnished for mounting any PUSH-PULL cable at the swivel terminal

Swivel Action



Standard assemblies have end fittings with a swivel movement of ± 8° to compensate for misalignment and rise or fall of lever arms. Swivel joints, and the sliding ends, are sealed against dirt and moisture.

PUSH-PULL DATA FILE SHOWS HOW TO SIMPLIFY, IMPROVE DESIGN

• Write for your PUSH-PULL Data File. It contains a complete set of engineering bulletins which describe in detail the operation of PUSH-PULL CONTROLS, their applications, features and advantages.

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what use for these

UNCONVENTIONAL POWER SOURCES?

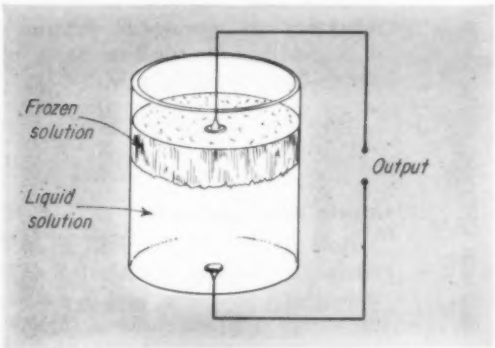
Though research has shown a variety of new ways to generate power (PE—June 26, p 51), several other possibilities remain. Here are eight. Although now only laboratory curiosities, some will probably find their way into commercial devices in the next few years.

CHARLES J LYNCH, *associate editor*

■ The power generators shown below are not likely to replace the battery, the engine-driven generator or even the new thermoelectric cells—at least not in the next 10 years. At their present stage of development they are too inefficient and the effects too weak to produce much in the way of useful power. Before they can compete, we will need to know much more about the physics of solids and how materials behave when subjected to high temperatures and strong electric and magnetic fields.

Meantime, they needn't be relegated to the back room of the lab. Many commercial devices depend on physical phenomena that are no more pronounced or efficient than these. Magnetostriction, for example, has found a place in ultrasonic vibration. The Hall effect, though weak, has been turned to good use in magnetic-field meters. There are many other examples: piezoelectricity for transducers, secondary electron emission for photomultipliers.

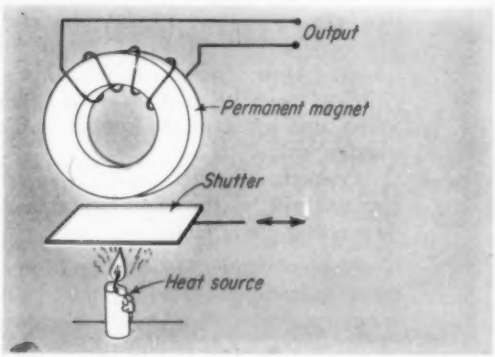
Given time and ingenuity, we can be confident that similar applications will be found for these little-known physical effects.



Workman-Reynolds effect

How it works: Freezing a solution of water and ammonia salts causes a potential to be generated across the ice-liquid interface. Any aqueous solution of an inorganic chemical will work. Voltage depends on solute concentration, current depends on freezing rate. Experimental tests have shown potentials of 230 v and currents of 1 ma.

Prospects: Unlikely as a practical source of power. Max theoretical efficiency appears to be about 14% but laboratory devices have done no better than 0.004%.



Thermomagnetic

How it works: Alternately heating and cooling a permanent magnet in the neighborhood of its Curie temperature (the point at which it loses its magnetism) causes a change of flux and generates a low-frequency current in the coil. Amount of power depends on rate of flux change—hence rate of heat absorption and rejection.

Prospects: Depends on two developments: discovering a method to heat and cool quickly, and finding a material with a sharp permeability gradient at its Curie temperature so that a small temperature swing will give a large flux change.

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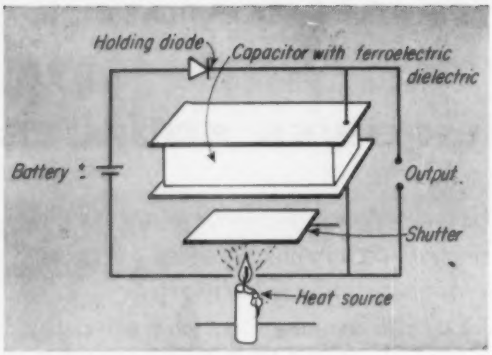
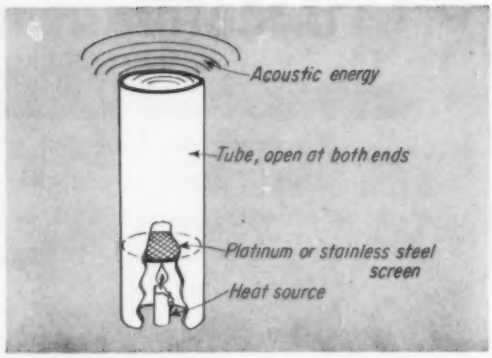


Ferroelectric converter

How it works: The dielectric constant of this ferroelectric (barium titanate, for example) changes with temperature, thus changing capacitance and voltage across capacitance. The change occurs at the Curie temperature (about 1000 C). In this circuit the diode prevents current from flowing back through the battery. The ferroelectric converter acts as a pump, forcing current through the load with changes in temperature. The battery can be eliminated if two converters are connected in push-pull so that the charge shuttles between them as they are alternately heated and cooled. In this arrangement, a small battery would be used to prime the capacitors initially and to make up for leakage current.

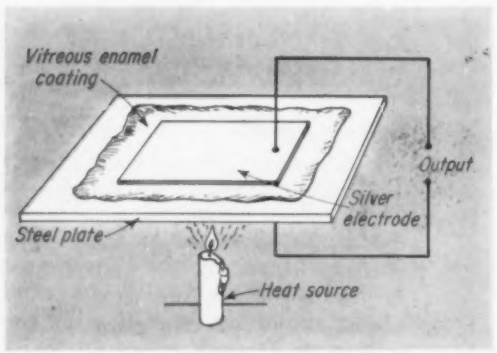
Prospects: Possible application in space power. Output and weight compare favorably with thermoelectric generators and solar cells.



Rijke tube

How it works: A heated screen mounted in this open-ended tube causes the column of air to vibrate producing acoustical energy. An experimental device built by Battelle Memorial Institute is about 3 ft long, 3 in. dia, has an electrically heated platinum screen set about 10 in. from the bottom of the tube. Why it works is not yet fully understood.

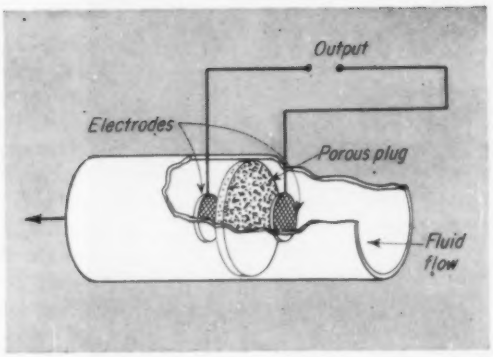
Prospects: Though inefficient as an energy converter, it may find application as an ultrasonic generator or as a remote warning device or noisemaker to scare away pests. Coupled to a variable reluctance on moving-coil acoustic transducer, it might produce small amounts of electrical power—but very inefficiently.



Austin effect generator

How it works: When heat is applied to the sandwich, a current is generated which lasts for as long as ½ hour after heat is removed. In this, the device acts more like a thermally charged battery than a thermoelectric cell. Experimental units have developed 16 mw/sq in. when heated to between 400 and 1400 F. The effect was discovered in 1959 by B. O. Austin of Westinghouse when testing dielectric properties of vitreous enamel insulations. The physical mechanism that produces the current is not yet well understood.

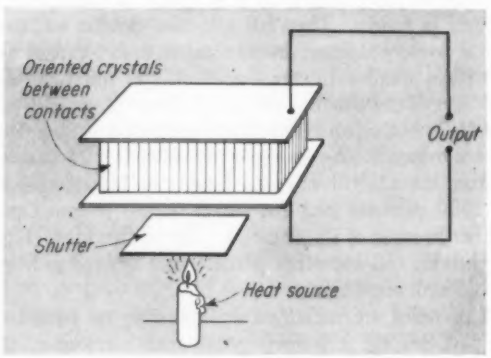
Prospects: Further study is needed before judging whether this effect can be developed into a practical power source.



Electrokinetic effect

How it works: When a fluid flows past a solid surface, a current is generated. This effect, also called "streaming potential", has been used to measure pressure variations in oil pipelines. It is most pronounced when the fluid in the pipe is forced through a porous solid and the potential measured between an electrode upstream of the obstruction and another electrode downstream.

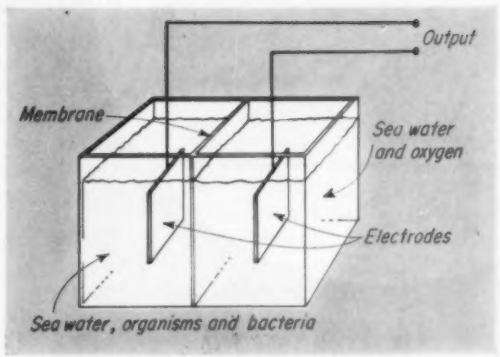
Prospects: Now being studied in several laboratories (Battelle Memorial Institute, Oklahoma A & M College) to determine effect of such parameters as thickness and porosity of plug, shape of pipe and electrodes.



Pyro-electric effect

How it works: When an oriented crystal such as tourmaline or tartaric acid is heated, a potential is generated between its two faces as it cools. Measuring the effect is complicated by a concurrent thermoelectric and piezoelectric effect.

Prospects: Generates only small amounts of power and is not considered a practical power source at present. Has been used to measure variations in temperature as small as 1 x 10^{-4} C.



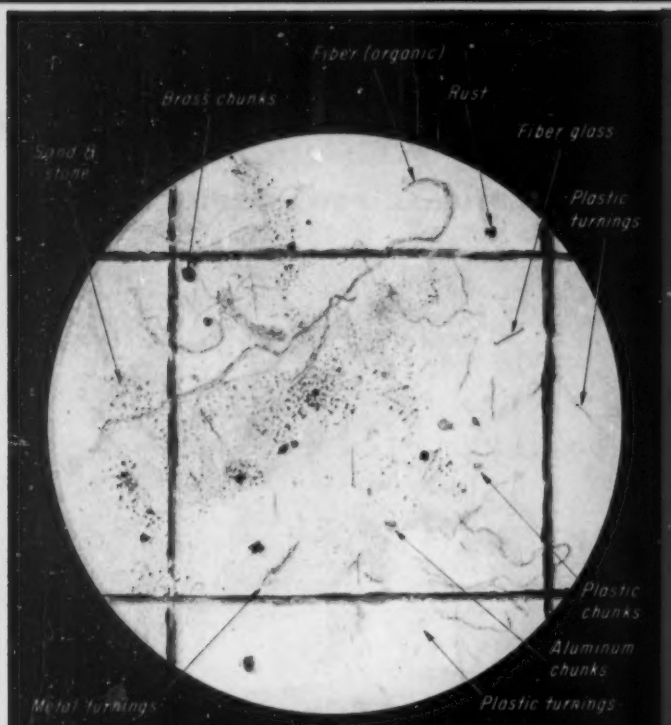
Organic fuel cell

How it works: Like an inorganic fuel cell except that it "burns" organic waste material (even sewage may be a potential energy source). Two approaches are now under study but both draw power from the same reaction: In a solution containing bacteria and a nutrient, the bacteria causes the nutrient to decompose, producing energy. In the cell shown above, organisms in seawater are the nutrient; in the other approach, sugar is the nutrient. Experimental cells of both types have generated up to 0.5v for periods of several months.

Prospects: Now being actively investigated by F. D. Sisler of the Interior Dept's Geological Survey (sea water cell) and Joseph Kaye & Co of Cambridge, Mass (sugar cell). There are many problems to be solved, chiefly the one of finding the best combination of nutrient and bacteria, and providing suitable conditions for their reaction. Its long life and simplicity promise to attract much interest among the armed services

For REPRINT of above article, just check 616 on one of the Reader Service cards found in this issue.

EDITOR'S NOTE: For a complete discussion of all the new methods for direct generation of electrical power, (fuel cell, MHD generator, thermoelectric generator, thermionic converter, solar cell) and a comparison with nine sources of mechanical power, see "Tomorrow's Power Sources," June 26, p 51.



Typical dirt particles – found in sealed containers of hydraulic oil – are a warning

7 DESIGN STEPS TO CLEANER FLUID SYSTEMS

Anticipate the contamination problems before they occur—and you can design a fluid system that won't fail. The author speaks from his experience in writing specs for clean fluid systems at Martin Co's missiles plant.

GORDON WENNER, *materials engineer The Martin Co, Denver*

■ Contamination can cause system failure in three ways: erosion, jamming, and chemical (or physical) reaction of the fluid with incompatible materials. Some contaminants are troublesome because they don't dissolve—others because they do! You cannot always predict which combinations of fluids, seals and contaminants will give trouble—failure reports from the field might be your first clue. But there are certain design steps you can take.

Design Procedure

1. **Design for dirt-tolerance**—To avoid contamination problems, the first and most important step is to design the hydraulic or pneumatic system to operate with a reasonably contaminated fluid. If particles over several hundred microns (1 micron = approx. 1/25,000 in.) can be tolerated, and dissolved foreign matter is no problem, then ordinary design and quality-control techniques will suffice.

But if a servo system or other fluid system cannot tolerate particles larger than 5, 10, or even 30 or 40 microns, specialized anti-contamination measures are needed. For one thing, be prepared to specify several filters in series for your system (70-micron, 40-micron, and 10-micron or smaller). And provide pumps with sufficient capacity to handle the resulting pressure losses. Then be sure you consider each of these final six steps:

2. **Contaminants**—Define the types of contamination expected. (Actual samples will be valuable.)

3. **Components**—Decide which components and seals will be most susceptible to damage.

4. **Flow**—Calculate maximum flow and pressure at susceptible points to see if special problems exist.

5. **On-stream time**—Decide how long the system must run between maintenance periods.

6. **Quality control**—Check quality-control facilities to be sure they are adequate.

7. **Costs**—Estimate over-all cost: components, system, quality-control.

Types of contamination

The table at right shows the wide range of solid-particle sizes found in fluids. They fall into two classes: a fibrous particle is loosely defined as any nonmetallic thread-like object with a small diameter (less than 100 microns) and a large length-to-diameter ratio. A fiber is usually organic, such as cotton and nylon (one exception is fiberglass, which is inorganic). An example of a fiber is a 25-micron-dia cotton thread 750 microns long. A 100-micron-dia thread 2000 microns long (of any material) is considered a non-fiber because of its diameter. Metal shavings, chips, plastic chunks, and any other particles not defined as fibers are considered non-fibers.

Solid particles are measured by counting or weighing. If the particles are extremely small and numerous, the most practical method is to weigh the entire mass of particulate matter at one time. Particle-count limits for commercial and military applications were given in a previous article (*PE*—Dec 19 '60, p 35).

Solubility depends on the contaminant and on the fluid. A given contaminant may dissolve in one fluid but not in another. Or it might dissolve harmlessly (the important fluid properties such as viscosity, chemical inertness, and electrical resistivity are not impaired) and it is no longer a contaminant. Salt (NaCl) remains solid (undissolved) in petroleum-based fluids, but dissolves in water-

based fluids. There are available lab techniques for accurately measuring the amount of dissolved contaminant in any hydraulic fluid, and suitable limits have been established for most fluids and systems.

Susceptible components

Close-fitting dynamic parts such as servo-type spool valves (clearances sometimes less than 10 microns) can be jammed with a single solid particle of any shape. Tiny orifices will often pass small fibers but clog if the contaminants are bulky. Gummy deposits are troublesome in any control device.

Dead-ended cavities and obstructions (ordinary fittings have them) can trap and accumulate particles, and should be avoided. High flow and rapid changes in flow and pressure may dislodge trapped particles, decreasing system reliability. One answer: manifolds instead of fittings.

Moving parts generate wear particles; but careful matching of material, hardness, and finish will reduce such wear. Compatibility of fluid and seals is critical, and should be determined by a chemist, or better yet, by actual field testing.

On-stream time

If a system can be easily and frequently cleaned, larger quantities of any given size of contaminant may be tolerated. If partial clogging of orifices is acceptable, and if ordinary vibration can be counted on to free spool valves if they momentarily jam, then larger particles might be acceptable. It is important to demand only the cleanliness required: more than this will prove expensive. It can cost five times the purchase price of a component to ensure absence of particles larger than 100 microns.

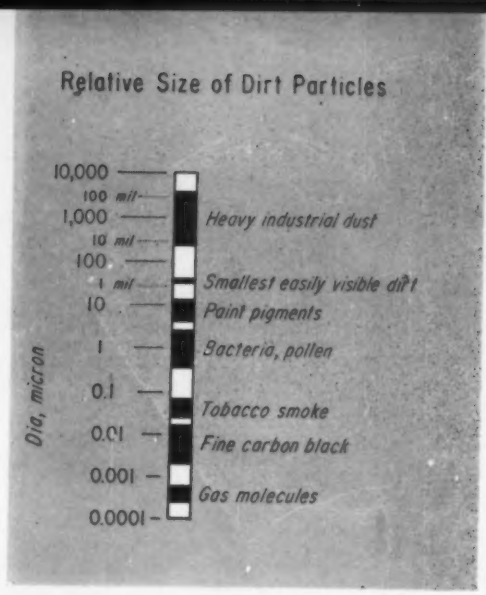
It is not usually possible to predict on-stream time from lab tests or prototype tests, even with purposely contaminated fluid. For one thing, the test fluid will not remain uniformly contaminated, and variables such as load, temperature, human interference (the test engineer will be too careful with the system), and local conditions will invalidate the results.

Field-failure reports on similar equipment are a much better guide. If the failures are predominantly from contamination, the system is under-designed. When very few are contamination failures, the design is probably good, and a little extra care will solve the problem. If there are no failures, perhaps the design is too expensive.

Quality control

It is important that component and system cleanliness be the responsibility of a single person or group. Try to have one member from design on this team. Here are the reasons: components "as-received" from any industrial manufacturer will rarely meet the barest minimum cleanliness requirements for an ordinary system, and will never meet stringent requirements, unless constant supervision is given. Even if components are delivered perfectly clean, it is not possible to assemble them into the system without adding some contamination from the atmosphere, assembly tools, and any of a dozen other dirt sources.

It takes a specialist to clean a system, and he must have thorough knowledge of each component, each seal material, function of the system, and knowledge of all the available cleaning solutions. (The safest cleaning agent is the system fluid itself—or one similar to it.)



Missile manufacturers have partly licked the over-all problem—they had to—but the solution is complicated and expensive. They make the suppliers install (or rent) elaborate cleaning facilities, then certify them to use the equipment after extensive training programs. Even so, cleaning-survey teams must travel around to witness the decontamination and packaging of critical components. Each missile manufacturer has a different set of criteria, he will not normally accept components certified by another missile manufacturer. Some progress toward universal acceptance procedures is being made by the Aerospace Industries Association in a coming handbook.

You can help ensure system cleanliness by insisting that all fluid be filtered or centrifuged just before delivery into the system. You can also specify temporary magnetic and conventional filters for clean-up during flushing, proper permanent system filters (*PE—Nov 28 '60, p 29*) and a suitable program of filter maintenance. Choice of fluid is the responsibility of the fluid manufacturer, but with his help you can predetermine the type that will give the best performance without compatibility problems.

Cost of quality control

System component costs are easy to get—once you establish the design. But quality-control cost figures are hard to estimate until long after the design is finished and the machines are in service. Rough estimates are possible; and of greatest importance is the "cross-over" point (in microns) where existing in-plant cleaning equipment is inadequate and new equipment must be purchased. You can save money by establishing these limits before designing the system. It might even be worth a redesign of the system to let the existing cleaning equipment do the job.

For example, suppose your plant's equipment can clean to 200 microns, but your best estimate of required cleanliness is 150 microns. Then, if the additional cost for new cleaning equipment is excessive, under the circumstances it might pay to sacrifice performance or increase maintenance costs by designing for 200-micron cleanliness.

There is no particular saving in allowing greater initial system contamination than the in-plant equipment can remove: it doesn't cost twice as much to clean down to 500 microns as it does down to 1000 microns—essentially the same equipment will do the job in either case. ■

specifying an elastomer for the first time?

you should ask . . .

WHAT GOES INTO RUBBER?

The filler being added to the rubber mix shown above may be only one of 10 or 20 ingredients needed for an engineered elastomer. Basic rules for design of rubber parts were covered in a previous article (Apr 10, p 60). Now, the author identifies the main ingredients in a rubber compound and tells what they do.

GEORGE McKENZIE
chief compounder
Minnesota Rubber Co
Minneapolis

■ Rubber, in the state in which it is produced, whether natural or synthetic, is practically worthless as an engineering material—weak, soft, and greatly affected by temperature. However, rubber technologists have discovered ways to add various substances in a compounding operation, thereby significantly altering the physical characteristics of the rubber.

Such practical rubber compounds contain two types of ingredients besides the base polymer. The first group serves the general functions of vulcanizing and stabilizing the polymer; the second group serves special purposes such as reinforcement, stiffening, bulking, softening or coloring.

Vulcanizers and rubbers

Natural rubber is usually vulcanized with sulfur, the most common of the vulcanizing agents. When natural rubber and sulfur are heated together, the reaction gives a product that is stronger, tougher, more wear-resistant, and less sensitive to temperature extremes than raw rubber. Early rubber compounds were normally composed of 100

ALTERED INGREDIENT = CHANGED RUBBER

By varying the nitrile content of the original elastomer, and keeping the other ingredients constant (as shown), two modifications can be developed that differ in their characteristics from the original. All three will have about the same hardness and other physical properties. Varying the content of carbon black and plasticizer would alter hardness.

Ingredients	Original	Modification No. 1	Modification No. 2*
	Characteristics: 1. Good cold resistance (brittle point, −65 F) 2. High swell (20%) in #3 oil	Characteristics: 1. Good oil resistance (swells 5% in #3 oil) 2. Poor cold resistance (brittle point, −20 F)	Characteristics: 1. Moderate oil resistance (swells 10 to 15%) 2. Fair cold resistance (b.p. is −50F)
Base polymer	100 parts Buna-N (20% nitrile)	100 parts Buna-N (40% nitrile)	100 parts Buna-N (30% nitrile)
Reinforcing filler	50 parts carbon black	same	same
Vulcanizer	1.5 parts sulfur	same	same
Accelerator	0.6 tetra-methylthiuram monosulfide		
Activator or retarder	5 parts zinc oxide with 1 part stearic acid		
Plasticizer	10 parts dibutyl-phthalate		
Aging retardant	1 part PBNA	same	same

* Makes a good general-purpose grade

parts of natural rubber, and 8 or 10 parts of sulfur. During vulcanization about 3% or 4% of sulfur combines with the rubber. The balance either remains in solution in the rubber or migrates to the surface. When natural rubber and sulfur are heated together in the proportion of about 68 parts of rubber to 32 parts of sulfur, the end product is hard rubber or ebonite. Natural rubber will react with sulfur in any proportion intermediate between the composition of soft, vulcanized rubber and ebonite.

Butyl rubber can be vulcanized with sulfur but it requires more time under vulcanizing conditions to reach a high state of cure.

Nitrile rubbers also can be vulcanized with sulfur, much the same as natural rubber, with the exception that their requirements for sulfur are lower. Here again, the gum vulcanizate is much weaker than the comparable natural rubber compound and needs a reinforcing filler. It does, however, possess higher resistance to aging, and to swelling in solvents.

Practical neoprene compounds employ certain metallic oxides, such as magnesium oxide and zinc oxide, as vulcanizing agents. These materials provide a good balance of properties and are commonly used together. Certain organic chemicals are used to accelerate the reaction and improve compression-set resistance.

Acrylic rubbers are also cured with an agent other than sulfur. These polymers require an amine such as triethylene tetramine, because sulfur retards the cure in the unvulcanized state. Sulfur is sometimes added to the compound to stabilize the cured stock in prolonged exposure to elevated temperatures.

All of the polymers discussed are in common use. Their properties are fairly well known and their areas of application are well defined. In the past few years a group of rubberlike materials has been developed that, for want of a more descriptive term, have been called the exotic rubbers. This group includes the urethanes, fluoro elastomers and silicones. These materials differ widely in chemical makeup, but conventional molding techniques and equipment (with slight modifications) can handle their fabrication. Because of their state of development, these materials are relatively expensive. However, as they come into more widespread use their cost will undoubtedly follow the downward trend of other synthetic rubbers. At present they are of primary interest in applications where the conventional elastomers will not give satisfactory service.

Other vulcanizing systems

Certain organic sulfur compounds are occasionally used as vulcanizers for both natural and synthetic rubbers. When exposed to heat these substances yield sulfur in a form suitable for vulcanization and have the advantage of being capable of bringing about a very rapid cure; however, the sulfur content of the vulcanized product is usually considerably less than in rubbers vulcanized with elementary sulfur.

Using such sulfur compounds rather than raw sulfur is generally termed a "sulfur-free" cure. This system is often confused with the so-called "sulfur-less" cure. Here, organic peroxides usually accomplish the vulcanization. Most common of these is dicumyl peroxide, a material satisfactory for curing neoprene, natural rubber, nitrile rubber, Hypalon, SBR, urethanes, polyacrylic elastomers, and silicones. It cannot be used on butyl rubbers and

polyisobutylene because they are depolymerized rather than vulcanized.

The mechanism of vulcanization with dicumyl peroxide appears to be the abstraction of hydrogens from the polymer, resulting in formation of a carbon-to-carbon bond between the two polymer molecules. In sulfur-curing the bond is carbon-to-sulfur-to-carbon. Some of the properties obtained from vulcanizates of the sulfur-less system are excellent compression-set resistance, good high-temperature aging characteristics, freedom from discoloration upon exposure to heat or ultra-violet light, better resiliency and better dynamic flex cracking at room temperature.

It is important to remember that this is a relatively new vulcanizing system. Therefore all ramifications of its uses are not yet known. This system will become increasingly important in commercial applications because of its unique properties.

Other compounding ingredients

To increase the rate of reaction in the vulcanization operation, organic accelerators, together with accessory fatty acids and zinc oxide, are employed. The fatty acid (such as stearic acid) provides a rubber soluble zinc salt necessary to the action of the organic accelerator. These materials not only increase rate reaction but also slightly modify the tensile properties and other physical characteristics of the vulcanizate, and often considerably improve the aging behavior.

Another effect of these materials is that much less sulfur is required than when sulfur is used alone. The amount of sulfur varies with the accelerator employed: less is needed with a powerful accelerator than with one having a mild action. The choice of accelerator also determines the temperature at which processing is carried out. The accelerator should be inactive at the temperature at which the rubber stock is mixed, but still be able to bring about rapid vulcanization at a temperature only 50 to 100 deg F higher.

The reinforcing filler is, by sheer bulk, one of the major components in a rubber compound. Carbon black is the most outstanding and the most common for both natural and synthetic rubbers. Its function is to increase tensile strength and resistance to abrasion. When natural rubber provided the bulk of the basic polymer, channel black (so-called because it was collected by burning a gas flame on a cold steel channel) was the principal type of carbon black used. With the advent of synthetic rubbers, furnace blacks came into extensive use because of the wide range of properties obtainable with them. Other finely divided fillers—clays, silicates and magnesium and calcium carbonates—also show a reinforcing action, but to a lesser extent than does carbon black. However, they often affect other properties such as tear resistance, and should only be utilized when the end use of the part is clearly known.

Inert fillers or diluents are occasionally specified when economy is of prime importance. With materials such as whiting talc, in fusorial earth, slate, flour and petroleum asphalt, it is possible to produce a higher volume of rubber at a lower cost. Many of these materials neither improve nor impair the useful properties of the rubber. Besides keeping the cost down, they can facilitate some manufacturing operations.

Waxes, resins, oils, tars, and high-boiling esters are added to rubber compounds as softeners or plasticizers. All of them serve to modify the properties—either to facilitate manufacturing, or to improve some property of the vulcanizate such as low-temperature resistance.

Color is not ordinarily considered in rubber parts for industrial applications. However, there are many products where it is desirable for reasons of coding or esthetics. For these, pigments will provide virtually the entire spectrum of colors.

Helping the compounder

Choosing among ingredients of the type discussed above, the rubber technologist designs the best possible formula for a specific application at the lowest possible cost. He may include as many as 10 to 20 different ingredients, each added to effect a property improvement, a cost saving, or an improvement in processing characteristics. The table on page 63 shows how modest changes in just one of these ingredients can create a spectrum of rubbers with widely different properties. To ensure that the compound is based on the right formula, the designer should be prepared to supply answers to these six questions:

1. What purpose and function does this part serve?
2. What forces will be applied to the part in compression, tension, shear pressure or flexure?
3. What does the part have to resist in terms of weather, temperature, fluids or abrasives?
4. What service life is expected of the part in its application: five minutes, five years; one cycle, one million cycles?
5. What the economic factors involved? Can the part afford the best material, or must it seek a compromise between best performance and economical cost?
6. What tolerances are expected? Can metalworking tolerances be avoided?

EDITOR'S NOTE: Other recent articles on the selection of elastomeric materials for engineering applications include:

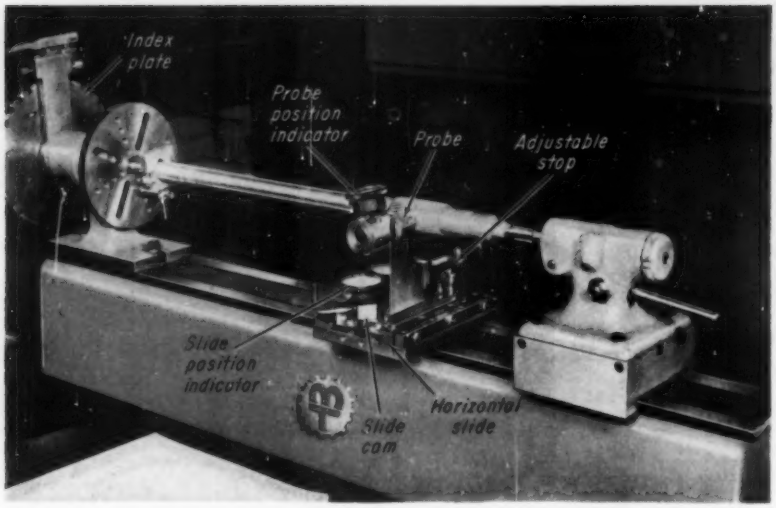
Selection Guide to High-damping Materials, Apr 17 '61, p 44—To control vibration in structures by applying viscoelastic materials, you must first know their dynamic properties and how they vary. Article surveys over 50 candidates.

How to Select the Right Gasket Material, Oct 3 '60, p 52—This 4-step procedure puts design emphasis where it belongs, on the total bolt force applied to the joint at installation.

Coatings and Fabrics for Today's Diaphragms, Oct 26 '59, p 68—You have to know all the types or you'll be designing diaphragms that don't meet the needs. Here, selection charts guide you to the right base fabric and rubber coating.

Comparison of Rubber Properties, Mid-Sep '59, p 112—Physical properties of elastomers can be varied by compounding; hardness, resilience, compressibility can be changed, permitting different applications for the same basic compound. Article compares 10 elastomers.

Today's Rules for Rubber-to-Metal Bonding, Aug 3 '59, p 52—Nearly any rubber can be bonded to almost any rubber, using established techniques plus modern adhesives. Article reports on how to obtain reliable bonds and desired tolerances.

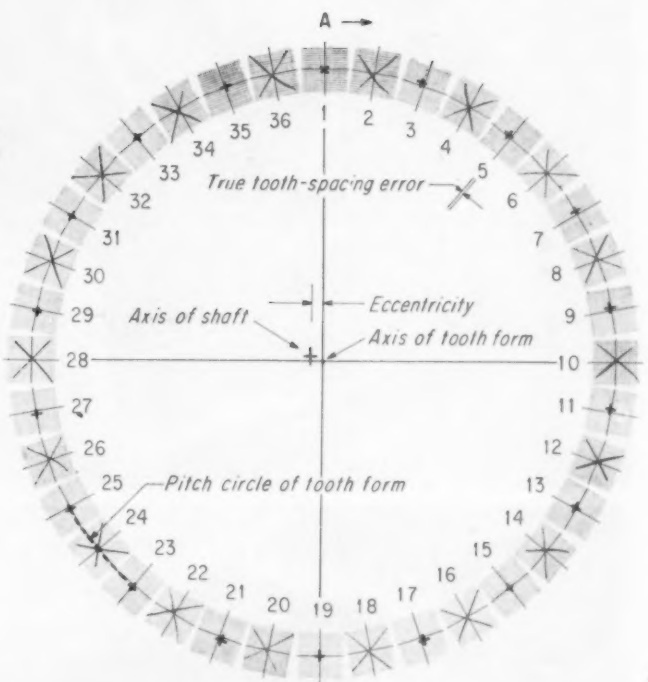


GEAR or spline to be checked is mounted between centers and positively positioned by an index plate. A rack type probe contacts both flanks of the tooth being checked at the pitch circle. Vertical movement of the probe is transmitted to the dial indicator through a pivoted lever. The reading on the dial indicates angular deviation or tooth spacing errors. The probe and its dial indicator can be rotated as a unit to match the helix angle of the work. Horizontal variation, or eccentricity, is measured by the cross slide on which the probe unit is mounted. A dial indicator on the slide contacts an adjustable stop attached to the base.

Graphic plot pinpoints gear errors

Simple measurement enables indexing and eccentricity errors to be separated mechanically. Light box and translucent error plot replace tedious arithmetic procedures previously used.

PS . . . Gear checker is used to measure pitch-line run-out and eliminate its effect on an index check. A short training session enables an operator to test toothed parts and determine tooth-spacing errors. Gear checking system is produced by Michigan Tool Co, Detroit.—JJK



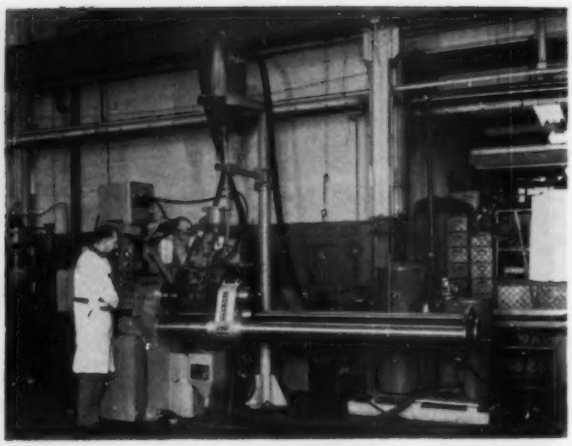
GEAR CHECKING begins when the operator locates two diametrically opposed teeth which give approximately similar readings on the slide position indicator. One of these two teeth is selected (starting point A on the chart) and the graph segment marked with an X. Using the handle on the slide cam the operator brings the pointer into contact with the first tooth A and zeros both indicators. This places the starting tooth on the mean of any run-out. The slide is withdrawn, the shaft indexed and the operator moves the slide forward again. New readings of both indicators are marked on the graph segment for the tooth (No. 3) by a plus sign. Space between lines on graph segments represents 0.0002 in. The radial bar of the plus sign records the reading taken from the tip pivot indicator and reflects angular variations. The cross bar of the plus sign records slide position and reflects deviation from pitch circle. This is repeated for each tooth. The plus-sign pattern recorded on the graph segments outlines the pitch circle of the gear or spline being checked. Since the gear being checked has only 18 teeth 18 graph segments are crossed out.

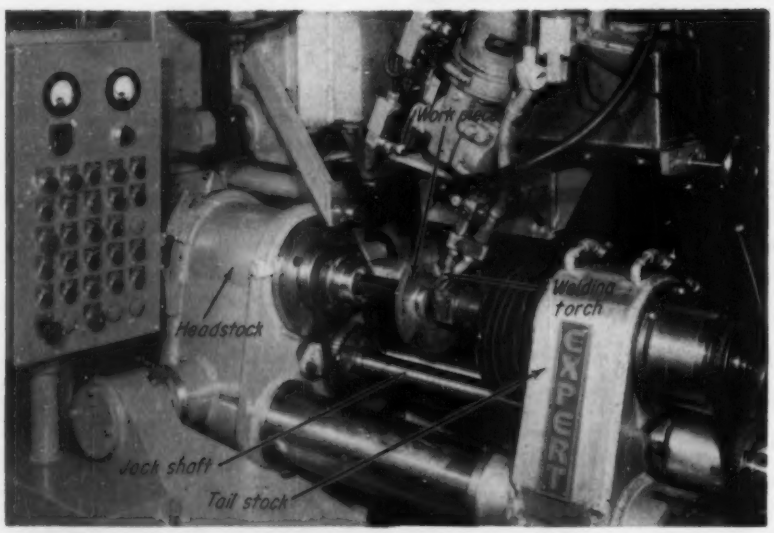
Using a light box, a blank chart is placed over the original and the centers of the first graph segments are super-imposed. The blank chart is pivoted around this point until its graph segment centers coincide, as closely as possible, with the plus-sign pattern on the original. The location of the center of the original chart and all plus signs are transferred onto the blank.

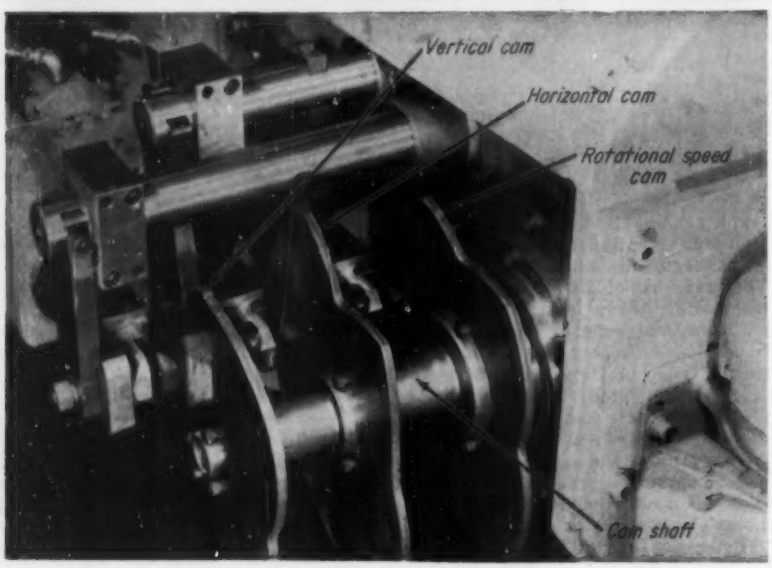
Gear errors can now be read directly from the chart tracing. Horizontal distance between centers represents eccentricity. Distance between traced plus signs and the center of each graph segment shows true tooth-spacing error with eccentricity errors removed.

Cams cure curves in welding

In this automatic welder for irregular shapes, they control speed and position of welding torch. Key to sound weld is constant linear speed along the weld, regardless of workpiece shape.





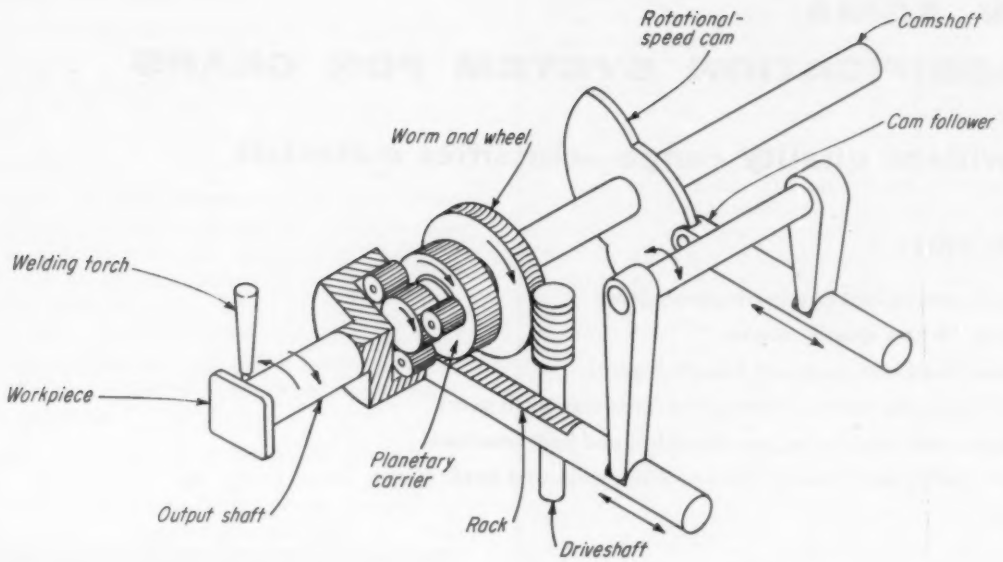


WORKPIECE is positioned and rotated between headstock and sliding tailstock. Submerged-arc welding torch is moved horizontally and vertically, as required, to maintain constant welding speed and gap. Tailstock is driven and synchronized by timing belts and pulleys on the jackshaft.

The three cam-controlled movements of the welder are interrelated to achieve: (1) Constant linear welding speed along weld contour, (2) Constant angle of torch to weld contour, (3) Constant angle of weld line to horizontal, (4) Constant electrode-to-work gap.

These requirements for good welding are achieved by incorporating a variable speed-of-part rotation, a variable horizontal-torch position, and a variable vertical-torch position. All three result from controlling the variables with simple plate cams that can be easily fabricated in the shop.

PS . . . Universal welder is used to make welds of irregular contour in a single plane. Besides controlling torch movement, the axis of rotation of the work holder can be raised from 0 to 45° and the torch tilted from top dead center to 45° above it. Contour welder shown handles work up to 6 in. dia and 6 ft long; is produced by Expert Welding Machine Co, Detroit.—JJK

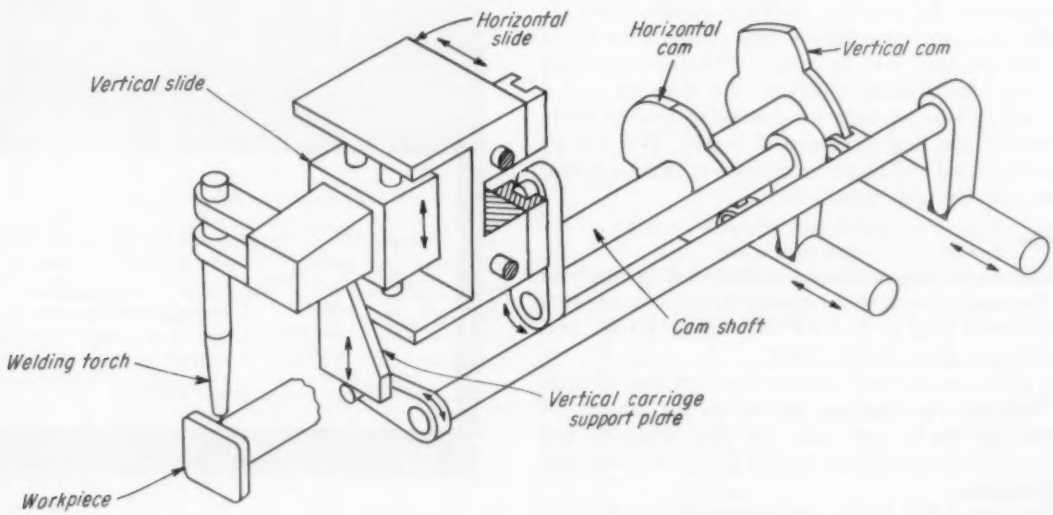


WORKPIECE, above, is rotated by an electric motor which drives the camshaft, through a worm and wheel, at constant speed. Mounted on this shaft are the rotational-speed cam and the sun gear of a planetary reducer. The output shaft is mounted on the internal gear of the planetary set.

The roller follower, which contacts the speed cam, is connected through levers and a rack to the planetary carrier. If the planetary carrier is rotated, while the sun gear rotates at constant velocity, the output shaft rotates at variable speed. Motion of the planetary carrier is algebraically added to uniform motion of the sun gear, giving required output-shaft speed. The planetary set is used to obtain a variable-speed output from a constantly rotating input and the cam-generated planetary carrier movement.

Horizontal torch movement or offset, below, is achieved by mounting the torch-supporting structure on a horizontal cam-controlled slide. The slide consists of ball bushings running on cylindrical rods. A roller follower on the horizontal cam actuates the slide through a bell crank. Any rise of the cam profile moves the slide in the direction of output-shaft movement.

Vertical torch movement is provided by a vertical slide mounted on the horizontal slide. This slide is driven by a plate cam which can be mounted on the camshaft or, if the shape permits, directly on the output shaft. If the part being welded has no concave sections the cam can be mounted directly on the output shaft. In this case a roller follower, mounted directly to the vertical slide, causes it to follow the desired contour. If the part has a concave section the output shaft rotates backward during part of its cycle. This backward rotation of the output would produce a double cam coordinate at a single cam point. To avoid this, the cam is mounted on the camshaft—which rotates in one direction, at a constant speed.



NEW AGMA CLASSIFICATION SYSTEM FOR GEARS . . .

. . . widens quality range—classifies materials

what it offers

- ✓ Covers spur, helical and herringbone gears
- ✓ Sets up 16 new quality classes
- ✓ Expands backlash classes of fine-pitch gears
- ✓ Establishes new backlash tolerances for coarse-pitch gears
- ✓ Assigns code numbers to gear materials and heat treatment
- ✓ Gives quality requirements for many industries and applications

NICHOLAS P CHIRONIS, *associate editor*

■ Here is the all-inclusive system for specifying gears that designers have been waiting for. It brings together data on fine- and coarse-pitch gears, and establishes a new quality classification system applicable to a wide span of precision —from "commercial" to "ultraprecision" types of gears. These terms have been obsoleted, and 16 classes of quality may be specified—the higher the number, the higher the quality.

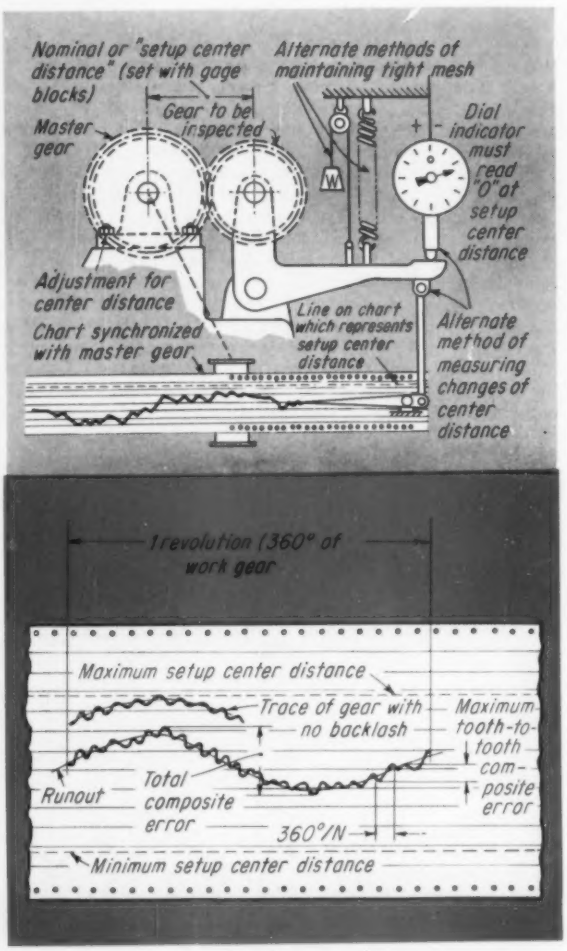
The new AGMA system also classifies, by means of a letter-number code system, popular gear materials and their heat treatment. In addition, backlash specifications for fine-pitch gears are classified in steps from A to E, as against the previous A to D system. Thus by combining the various classification numbers, the designer has a simple and easy-to-use code for specifying quality, backlash, material and heat treatment of a gear. This will go a long way toward building a better communication bridge between gear user and manufacturer.

Its scope

The new system covers spur, helical and herringbone gears. In many cases, it gives separate data for coarse-pitch gears; from 0.5 P to 19.99 P (P = diametral pitch); and fine-pitch gears, from 20 P to 200 P.

Four areas are covered: quality classifications of gear teeth; backlash classifications relating to the amount of tooth-thinning to be built into the gear; materials and heat-treatment classifications; typical quality requirements of applications.

At the end of this article are examples of how to combine the various codes to call out a complete set of specifications.


Nominal or "setup center distance" (set with gage blocks)
Alternate methods of maintaining tight mesh
Gear to be inspected
Master gear
Dial indicator must read "0" at setup center distance
Adjustment for center distance
Chart synchronized with master gear
Line on chart which represents setup center distance
Alternate method of measuring changes of center distance
1 revolution (360° of work gear
Maximum setup center distance
Trace of gear with no backlash
Maximum tooth-to-tooth composite error
Runout
Total composite error
360°/N
Minimum setup center distance

GEAR-ROLLING is the preferred way to inspect quality of fine-pitch gears. The new quality specifications give permissible tooth-to-tooth and total composite errors.

Quality numbers—fine-pitch gears

Quality numbers refer to the degree of precision applied to making the gear teeth. The new system eliminates the confusing terms "commercial" and "precision." Table 1 shows both the former and present quality designations.

Tolerances for the new quality designations, Table 2, are given in terms of:

Tooth-to-tooth composite tolerance. This is the allowable center distance variation as the gear is rotated in tight mesh with a master gear for one complete revolution of the gear. It includes effects of variations in circular pitch, thickness and profile.

Total composite tolerance. This is the allowable total variation in center distance as the gear is rotated with the master. It includes the effect of all tooth and runout (gear eccentricity) variations.

Both terms are illustrated at left. The gear to be inspected is held in tight mesh with a master gear in a gear-rolling fixture. Variations in the center distance are recorded on a chart (or observed on a dial indicator), and then compared with the acceptable deviations (tolerances) in Table 2. A perfect gear would produce a straight line on the chart—there would be no changes in center distance.

At present, there has been no need to classify fine-pitch gears with tolerances wider than those for Quality 5. Table 2 starts with this grade.

Quality numbers—coarse-pitch gears

The new system lists tolerances for quality numbers from 3 to 15. Quality 16 has been left open for future needs. Included are tolerances for runout, pitch, profile and lead. Also, for quality numbers from 8 to 12, the total-composite tolerance is given. If this is specified, it should

text continued, next page

WHY THE CHANGE?

■ In many instrument and control applications, gears have become the limiting factor of over-all system accuracy. Until now, the AGMA (American Gear Manufacturers Association) standard on fine-pitch gears (AGMA 236.04) provided for only seven quality classes—four classes of "commercial" gears, and three of "precision" gears. The standard did not include material specifications, nor did the quality classes satisfy the need for more precise gears in specialized applications.

Then, in a PRODUCT ENGINEERING article (Dec 22 '58, p 46), Lou Martin, well-known gear expert and member of several AGMA technical committees, proposed a classification system for quality of fine-pitch gears that could easily be extended in the ultraprecision direction. At that time he envisioned a 15-class system with tolerances that decrease logarithmically in preferred-number steps. He employed the terms "commercial," "precision" and "ultraprecision"—but suggested that these terms be dropped in favor of a code system to range from 1 to 15. The article raised objections from some gear manufacturers that to establish tolerances and assign code numbers to ultraprecise gears (a grade of quality not in the standards at that time) would encourage gear designers to specify such gears—and the gear industry had sufficient difficulty mass-producing Precision 3 gears (the best listed).

But it was only a matter of time. In Oct '59, an AGMA committee worked up a new standard, containing a 16-class quality range, and applicable to coarse-pitch as well as fine-pitch gears. It was routed to company members, but ran into resistance from some of the fine-pitch gear manufacturers. Main complaint: it failed to go far enough in eliminating gear specification problems. Many of the suggestions that resulted, including requests to improve the backlash classifications, were incorporated into it, and reaction last month at the AGMA meeting in Hot Springs, Va, was favorable. The system is now issued as the "Gear Classification Manual (AGMA 390.01) for Spur, Helical and Herringbone Gears." It obsoletes the two previous standards: AGMA 236.04 "Inspection of Fine-Pitch Gears," and AGMA 231.02 "Inspection of Coarse-Pitch and Helical Gears." However, portions of AGMA 236.04 dealing with inspection procedure are being retained under a new number, AGMA 236.05.■

IS IT MANUAL OR STANDARD?

■ Although AGMA cautiously refers to the new system as a manual, to all practical purposes it will function as a standard. The two previous standards it obsoletes were, in fact, so designated by AGMA.

Why the reluctance now? Primarily because some of the new quality classifications call for extremely tight tolerances. This is bound to be troublesome for some manufacturers. The AGMA is a looser organization than that of the technical societies. If a manufacturer does not approve a standard he may pull out of the organization. This has happened before. Technical committees setting up standards have learned to proceed slowly. This classification system is a big step. By referring to it as a manual, the manufacturer is presented with a guide post rather than a directive.

But the American Standards Association (ASA) has indicated interest in adopting the new system as an ASA standard. ASA has done this previously with other AGMA publications. Thus, unless a change is made in nomenclature, the AGMA may find itself offering the gear designer a "manual," while the ASA is offering the same contents as a "standard." ■

TABLE 1—FORMER AND PRESENT QUALITY DESIGNATIONS FOR FINE-PITCH GEARS

Former designation	Present Quality No.
Commercial 1	5 or 6
Commercial 2	6 or 7
Commercial 3	8
Commercial 4	9
Precision 1	10 or 11
Precision 2	12
Precision 3	13 or 14

Table 2—Fine-pitch gear tolerances (in inches)

AGMA Quality No.	No. of Teeth, T and Pitch Diameter	Diametral Pitch Range	Tooth-to-tooth Composite Tolerance	Total Composite Tolerance
5	Up to 20 T (inclusive)	20 to 80	0.0037	0.0052
	Over 20 T; to 1.999 in.	20 to 32	0.0027	0.0052
	Over 20 T; 2 to 3.999 in.	20 to 24	0.0027	0.0061
	Over 20 T; 4 in. and over	20	0.0027	0.0072
6	Up to 20 T	20 to 200	0.0027	0.0037
	Over 20 T; to 1.999 in.	20 to 48	0.0019	0.0037
	Over 20 T; 2 to 3.999 in.	20 to 32	0.0019	0.0044
	Over 20 T; 4 in. and over	20 to 24	0.0019	0.0052
7	Up to 20 T	20 to 200	0.0019	0.0027
	Over 20 T to 1.999 in.	20 to 100	0.0014	0.0027
	Over 20 T; 2 to 3.999 in.	20 to 48	0.0014	0.0032
	Over 20 T; 4 in. and over	20 to 40	0.0014	0.0037
8	Up to 20 T	20 to 200	0.0014	0.0019
	Over 20 T; to 1.999 in.	20 to 200	0.0010	0.0019
	Over 20 T; 2 to 3.999 in.	20 to 100	0.0010	0.0023
	Over 20 T; 4 in. and over	20 to 64	0.0010	0.0027
9	Up to 20 T	20 to 200	0.0010	0.0014
	Over 20 T; to 1.999 in.	20 to 200	0.0007	0.0014
	Over 20 T; 2 to 3.999 in.	20 to 200	0.0007	0.0016
	Over 20 T; 4 in. and over	20 to 120	0.0007	0.0019
10	Up to 20 T	20 to 200	0.0007	0.0010
	Over 20 T; to 1.999 in.	20 to 200	0.0005	0.0010
	Over 20 T; 2 to 3.999 in.	20 to 200	0.0005	0.0012
	Over 20 T; 4 in. and over	20 to 200	0.0005	0.0014
11	Up to 20 T	20 to 200	0.0005	0.0007
	Over 20 T; to 1.999 in.	20 to 200	0.0004	0.0007
	Over 20 T; 2 to 3.999 in.	20 to 200	0.0004	0.0009
	Over 20 T; 4 in. and over	20 to 200	0.0004	0.0010
12	Up to 20 T	20 to 200	0.0004	0.0005
	Over 20 T; to 3.999 in.	20 to 200	0.0003	0.0005
	Over 20 T; 2 to 3.999 in.	20 to 200	0.0003	0.0006
	Over 20 T; 4 in. and over	20 to 200	0.0003	0.0007
13	Up to 20 T	20 to 200	0.0003	0.0004
	Over 20 T; to 1.999 in.	20 to 200	0.0002	0.0004
	Over 20 T; 2 to 3.999 in.	20 to 200	0.0002	0.0004
	Over 20 T; 4 in. and over	20 to 200	0.0002	0.0005
14	Over 20 T	20 to 200	0.00019	0.00027
	Over 20 T; to 1.999 in.	20 to 200	0.00014	0.00027
	Over 20 T; 2 to 3.999 in.	20 to 200	0.00014	0.00032
	Over 20 T; 4 in. and over	20 to 200	0.00014	0.00037
15	Up to 20 T	20 to 200	0.00014	0.00019
	Over 20 T; to 1.999 in.	20 to 200	0.00010	0.00019
	Over 20 T; 2 to 3.999 in.	20 to 200	0.00010	0.00023
	Over 20 T; 4 in. and over	20 to 200	0.00010	0.00027
16	Up to 20 T	20 to 200	0.00010	0.00014
	Over 20 T; to 1.999 in.	20 to 200	0.00007	0.00014
	Over 20 T; 2 to 3.999 in.	20 to 200	0.00007	0.00016
	Over 20 T; 4 in. and over	20 to 200	0.00007	0.00019

generally be in lieu of the other tolerances because a composite check is sufficient to tie down the gear-tooth errors. However, the coarser pitch gears, and those of the lower quality number, are not checked by means of a rolling fixture; hence the need for the other tolerances.

The key tolerances for qualities 8 to 15 for coarse-pitch gears are shown in Table 3.

Why the need for backlash

Backlash is the amount by which the width of a tooth space exceeds the thickness of the engaging tooth on the pitch circles. Backlash can be caused by machining variations in the center distance between gears, play in bearings, deflection under load, gear-tooth wear, etc.

Backlash is also "built-in" the gears by deliberately

text continued on page 72

Table 3—Coarse-pitch gear tolerances (in ten-thousandths of an inch)

AGMA Quality Number	Normal Diametral Pitch	Total Composite Tolerance						
		Pitch Diameter (inches)						
		1	3	6	12	25	50	100
8	2				80	94	111	135
	4		46	52	58	68	79	93
	8	35	38	42	46	52	60	70
	16–19.99	27	30	34	37	44	50	58
9	2				57	66	78	95
	4		33	37	42	48	54	66
	8		27	30	33	38	43	50
	16–19.99	19	22	24	27	31	36	42
10	2				40	48	58	69
	4		23	26	29	34	39	47
	8		19	21	24	26	30	35
	16–19.99	14	15	17	19	22	26	30
11	4		17	18	21	24	28	34
	8		14	15	17	19	22	26
	16–19.99	10	11	12	14	16	18	21
12	4		12	13	15	17	20	25
	8		10	11	12	13	15	18
	16–19.99	7	8	9	10	11	13	16

AGMA Quality Number	Normal Diametral Pitch	Pitch Tolerance Pitch Diameter (Inches)						
		1½	3	6	12	25	50	100
13	2			2½	2¾	2¾	3¼	3½
	4		2	2	2½	2½	2¾	3
	8	1¾	1¾	2	2	2¼	2½	2¾
	16–19.99	1½	1½	1¾	1¾	1¾	2	2¼
14	2			1¾	1¾	2	2¼	2½
	4		1½	1½	1½	1¾	2	2¼
	8	1½	1½	1½	1½	1½	1¾	2
	16–19.99	1½	1½	1½	1½	1½	1½	1¾
15	2			1½	1½	1½	1½	1¾
	4		1½	1½	1½	1½	1½	1½
	8	1½	1½	1½	1½	1½	1½	1½
	16–19.99	1½	1½	1½	1½	1½	1½	1½

Table 4—Backlash tolerances for fine-pitch gearing (in inches, measured in normal plane)

Backlash Designation	Normal Diametral-pitch Range	Tooth Thinning to Obtain Backlash (per gear)	Resulting Approximate Backlash (per pair)
A	20 thru 45	0.0020	0.0040 to 0.0080
	46 thru 70	0.0015	0.0030 to 0.0070
	71 thru 90	0.0010	0.0020 to 0.0055
	91 thru 200	0.0008	0.0015 to 0.0030
B	20 thru 60	0.0010	0.0020 to 0.0040
	61 thru 120	0.0008	0.0015 to 0.0030
	121 thru 200	0.0005	0.0010 to 0.0020
C	20 thru 60	0.0005	0.0010 to 0.0020
	61 thru 120	0.0004	0.0008 to 0.0015
	121 thru 200	0.0003	0.0006 to 0.0010
D	20 thru 60	0.0003	0.0006 to 0.0010
	61 thru 120	0.0002	0.0004 to 0.0007
	121 thru 200	0.0001	0.0002 to 0.0004
E	All Pitches	Do not provide tooth thinning	0.0000 to 0.0002

Table 5—Backlash tolerances for coarse-pitch gearing

(in inches, measured in normal plane)

Center Distance	Normal Diametral Pitches				
	0.5-1.99	2-3.49	3.5-5.99	6-9.99	10-19.99
Up to 5	.....	.....	.....	.....	0.005-.015
Over 5 to 10	.....	.....	.....	0.010-.020	0.010-.020
Over 10 to 20	.....	.....	0.020-.030	0.015-.025	0.010-.020
Over 20 to 30	.....	0.030-.040	0.025-.030	0.020-.030	.....
Over 30 to 40	0.040-.060	0.035-.045	0.030-.040	0.025-.035	.....
Over 40 to 50	0.050-.070	0.040-.055	0.035-.050	0.030-.040	.....
Over 50 to 80	0.060-.080	0.045-.065	0.040-.060	.....	.....
Over 80 to 100	0.070-.095	0.050-.080	.....	.....	.....
Over 100 to 120	0.080-.110	.....	.....	.....	.....

thinning the tooth thickness. This avoids a tight mesh because of incorrect mounting distance or because of gear expansion caused by an increase in the operating temperature. A tight mesh may result in objectionable gear noise, increased power losses, over-heating, rupture of the lubricant film, overloaded bearings and premature gear failures. There are gearing applications where a tight mesh (zero backlash) is required. On the other hand, specifying unnecessarily close backlash tolerances will increase the cost of the gears.

Fine-pitch backlash classifications

Two key changes in backlash in the new table, Table 4, from the previous standard are:

Backlash designations have been expanded from the previous *A* to *D* designations to the present *A* to *E*.

Previously, designation *D* called for no measurable backlash. Some gear manufacturers complained that although they could do better than *C* without too much difficulty, to achieve *D* greatly increased the cost of the gear. One manufacturer (*PE—June 6 '60, p 20*) came out with a *CD* backlash designation for gears with backlash between *C* and *D*.

The new system follows essentially this reasoning by shifting the previous *D* designation to *E*, and then adding new, in-between tolerances to *D*.

A new column has been added giving the amount of tooth-thinning built into the gear. Previously the table gave only the backlash in the normal plane.

Backlash does not affect the quality of a gear. Referring to the chart on p 68, the top trace has no backlash (backlash is measured at point of closest engagement). The second trace has a certain amount of backlash, resulting in a reduction in center distance. Both show the same total composite, and tooth-to-tooth deviations; hence both are rated the same, as far as quality goes.

Coarse-pitch backlash specifications

The backlash table for coarse-pitch gears, Table 5, is based on center-distance dimensions (indicative of gear size) rather than on gear pitch, as for the fine-pitch data, Table 4. In addition, the table gives only the normal-plane backlash; there is no information on tooth-thinning. Also missing are code letters to easily indicate the desired backlash. This means that the coarse-pitch gear designer must specify the actual backlash dimension because the new AGMA system specifically states that "definite backlash tolerances on coarse-pitch gearing shall be considered binding on the gear manufacturer only when agreed upon in writing" (a similar statement covers the fine-pitch gears).

Material and treatment

Code numbers have been assigned to a list of popular material and treatment combinations, Table 6. Nonmetallics are not included, but it is expected that the tables will be expanded as the need arises.

Although no attempt is made to relate material-treatment combinations to particular applications, these suggestions are offered by the AGMA:

Carbon steels, annealed from bar stock, forgings, or castings are usually satisfactory for pinion and gear when the loads are uniform, or moderate shock and the size of the gearing is not an important factor.

Alloy-steel lengthens the life expectancy of pinions. They may be used with cast iron gears, or with annealed, forged or cast steel gears where the ratio is about 6:1 or higher.

Alloy-steel pinions and gears, heat-treated, cut down space requirements by permitting smaller centers and face width.

Specify minimum hardness on steel pinions to be 40 Bhn higher than minimum hardness on the gear, for ratios from 2:1 to 8:1 when both are heat-treated. For ratios below 2:1 they are generally made to the same hardness.

For convenience of the heat treater, a range of 40 Bhn should be specified. For example, a pinion might be specified with a range from 265-305 Bhn and the mating gear 225-265 Bhn.

Where considerable impact loads exist, the use of alloys, plus lowering the hardness to a 50-56 Rc range, are recommended for carburized gears and pinions.

Where accelerated wear is encountered in service, heat

Table 6—Classification of materials

Designation Number	Treatment	Hardness Range
CARBON STEEL		
U-1	Anneal	180 BHN
H-1	Normalize and Temper	210–250 BHN
H-2	Quench and Temper	225–265 BHN
H-3	"	245–285 BHN
H-4	"	265–305 BHN
H-5	"	285–325 BHN
H-6	"	300–340 BHN
F-1	Flame-harden	43 Rc Min.
F-2	Flame-harden	48 Rc Min.
F-3	"	52 Rc Min.
F-4	"	55 Rc Min.
IN-1	Induction-harden	43 Rc Min.
IN-2	"	48 Rc Min.
IN-3	"	52 Rc Min.
IN-4	"	55 Rc Min.
C-1	Cyanide	55 Rc Min.
CN-1	Carbonitride	55 Rc Min.
CH-1	Carburize	48 Rc Min.
CH-2	"	50 Rc Min.
CH-3	"	55 Rc Min.
CH-4	"	58 Rc Min.
CH-5	"	60 Rc Min.
ALLOY STEEL		
U-11	Anneal	180 BHN
H-11	Normalize and Temper or Quench and Temper	225–265 BHN
H-12	Quench and Temper	245–285 BHN
H-13	Quench and Temper	265–305 BHN
H-14	"	285–325 BHN
H-15	"	300–340 BHN
H-16	"	335–375 BHN
H-17	"	350–400 BHN
H-18	"	400–450 BHN (43–48 Rc)
F-11	Flame-harden	43 Rc Min.
F-12	"	48 Rc Min.
F-13	"	52 Rc Min.
F-14	"	55 Rc Min.
IN-11	Induction-harden	43 Rc Min.
IN-12	"	48 Rc Min.
IN-13	"	52 Rc Min.
IN-14	"	55 Rc Min.
C-11	Cyanide	55 Rc Min.
CN-11	Carbonitride	55 Rc Min.
N-11	Nitride	48 Rc Min.
N-12	Nitride	64 Rc Min.
CH-11	Carburize	48 Rc Min.
CH-12	"	50 Rc Min.
CH-13	"	55 Rc Min.
CH-14	"	58 Rc Min.
CH-15	"	60 Rc Min.
NODULAR IRON		
N1-1	Anneal	180 BHN Min.
N1-2	Anneal or Normalize and Temper	210 BHN Min.
N1-3	"	225 BHN Min.
N1-4	"	245 BHN Min.
N1-5	Quench and Temper	255 BHN Min.
N1-6	"	265 BHN Min.
N1-7	"	270 BHN Min.
N1-8	"	280 BHN Min.
N1-9	"	285 BHN Min.
N1-10	"	300 BHN Min.
N1-11	Quench and Temper	315 BHN Min.
N1-13	"	350 BHN Min.
N1-14	Flame-harden or Induction-harden	48 Rc Min.
STAINLESS (300 SERIES)		
S-1	None Required	.....
STAINLESS (400 SERIES)		
S-2	None Required	.....
STAINLESS (410, 416, 440)		
S-3	Quench and Temper Induction-harden or Bright-harden	as specified
STAINLESS (440)		
S-4	Harden and Temper Induction-harden or Bright-harden	as specified
TIN BRONZE CASTING		
B-1	As-cast	60 BHN Min. (500 Kg)
MANGANESE BRONZE		
B-2	As-cast	121 BHN Min.
B-3	"	163 BHN Min.
B-4	"	187 BHN Min.
ALUMINUM BRONZE		
B-5	As formed or Heat-treated	143 BHN Min.
B-6	Heat-treated	179 BHN Min.
NICKEL ALUMINUM BRONZE		
B-7	Heat treated	197 BHN Min.
ALUMINUM BAR (2017-T4)		
A-2	Heat-treated	105 BHN (500 Kg)
ALUMINUM BAR (2024-T4)		
A-4	Heat-treated	120 BHN (500 Kg)
ALUMINUM SHEET (2017-T3)		
A-1	Heat-treated	.....
ALUMINUM SHEET (2024-T3)		
A-3	Heat-treated	120 BHN (500 Kg)
ALUMINUM BAR OR SHEET (6061-T6)		
A-5	Heat-treated	95 BHN (500 Kg)
HH BRASS		
BR-1	As-rolled	.....
NONMETALLIC		
NM	.....	.....

treating to obtain higher hardness will, in most cases, help reduce wear. Gears are usually made from stainless steels, brass, bronze, aluminum and nonmetal materials for applications where the power transmitted is relatively light, such as cameras, electronic instruments, control and guidance systems, radar, and meters.

For small power-tool applications subject to severe service, gears are usually made from carbon steels and hardened to various ranges such as Ch-1 to Ch-4, or induction-hardened to IN-2 and IN-3, or alloy steels IN-11 and IN-12. In cases where more hardness is required, alloy steels are used, carburized to CH-11 and CH-14.

Recommended quality numbers

The AGMA has gathered the quality requirements of many industries and applications. These are grouped in Table 7 under fine-pitch and coarse-pitch applications. To keep cost down, use the lower quality number shown.

AGMA class numbers

When specifying a gear, call for the AGMA class number, obtained by combining the designations for quality, backlash and material. A typical class number for fine-pitch gear is 10C-A-4.

This specifies that the gear is to be made to quality 10, backlash designation C, and of aluminum bar 2024-T4, heat-treated to 120 Bhn.

For coarse-pitch gears, all gear-tooth tolerances need not be made to the same quality number. For example the class number:

8-CH-15 (except pitch-quality 10)

specifies quality 8 tolerances except for pitch, which is made to tigher (quality 10) tolerances. ■

Table 7—Quality numbers for gear applications

Fine-pitch applications	Quality Number
COMPUTING & ACCOUNTING MACHINES	
Accounting-Billing	9–10
Adding Machine-Calculator	7–9
Comptometer	6–8
Computing	10–11
Data Processing	7–9
Typewriter	8
INSTRUMENTS & CONTROLS	
Accelerometer	10–12
Aircraft Instrument	12
Computers	10–14
Anti-Aircraft Detector	12
Automatic Pilot	9–11
Radar-Sonar-Tuner	10–12
Recorder-Telemeter	10–12
Servo System Component	9–11
Sound Detector	9
Transmitter-Receiver	10–12

Coarse-pitch Applications	Quality Number
AEROSPACE	
Control Gearing	7–11
Engine Accessories	10–13
Small Engines	12–13
AGRICULTURE	5–7
AIR COMPRESSOR	10–11
CONSTRUCTION EQUIPMENT	
Cranes, Open Gearing	3–6
Enclosed Gearing	6–8
Ditch Digger; Transmission	6–8
ENGINES	
Combustion, Engine Accessories	10–12
Timing Gearings	10–12
Transmission	8–10
FOUNDRY INDUSTRY	5–6
MACHINE TOOL INDUSTRY	
Hand Motion	6–9
Power Drives, 0–800 fpm	6–8
800–2000 rpm.	8–10
2000–4000 fpm	10–12
Over 4000 fpm	12 & up
Accurate Indexing	12 & up

Fine-pitch applications	Quality Number
HOME APPLIANCES	
Blender	6–8
Mixer	7–9
Washing Machine	8–10
PHOTOGRAPHIC EQUIPMENT	
Commercial, 8–10; Aerial	10–12
SMALL POWER TOOLS	
Bench Grinder	6–8
Drills-Saws	7–9
Sander-Polisher	8–10
MISCELLANEOUS	
Clocks	6
Counters	7–9
Gages	8–10
Motion-picture Equipment	8
Pumps	5–7
Vending Machines	6–7

Coarse-pitch Applications	Quality Number
MARINE INDUSTRY	
Accessories	5–8
Small Propulsion	10–12
METAL WORKING	5–8
OVERHEAD CRANES	5–6
PRECISION GEAR DRIVES	
Diesel Electric Gearing	8–9
High Speed Reels	8–9
Locomotive Timing Gears	9–10
Pump Gears	8–9
Turbine	9–10
PRINTING INDUSTRY	9–7
PUMP INDUSTRY	
Liquid	10–12
Rotary, vacuum	6–8
Slush-duplex-triplex	6–8
RADAR AND MISSILE	
Antenna Elevating	8–10
Data Gear	10–12
Ring Gear	9–12
Rotating Drive	10–12

For REPRINT of above article, just check 615 on one of the Reader Service cards found in this issue.

EDITOR'S NOTE: Tables 1, 2, 4, 5 and 6 are published in entirety from corresponding tables in the Manual. Some changes have been made in styling. Also, the material designations in Table 6 have been reorganized to provide quicker reference to specific materials.

Tables 3 and 7 have been excerpted from more complete tables in the Manual. Copies of the Manual are obtainable from AGMA, No 1 Thomas Circle, N. W., Washington 5, DC, at $1.50 per copy.

Many of Lou Martin's suggestions (p 69) for enlarging the span of quality specifications are incorporated into the above classification system. However, for more about his proposal, see his article:

New Standards for Gears Span Wide Range of Quality, Dec 22 '58, p 146.

Martin's article sparked a counter proposal from a prominant gear manufacturer. His view—the need for ultra-precision hasn't arrived yet, and additional classes will only add to the confusion. He offered new tables that directly give shaft-center tolerances for each class. See:

The Other Side of the Precision Controversy—A Workable Approach to Gear Tolerances, May 25 '59, p 52.

Both these approaches, however—and the present new classification system—fail to correct some basic faults in the AGMA system. Back in '56, George Michalec of General Precision analyzed them and described some remedies, still useful. See:

Methods of Specifying Precision of Spur Gears, Nov '56, p 135.

Michalec also tackled the problem of relating the AGMA system to over-pin measurements of gears which is still employed by the smaller companies who do not purchase gears in sufficient volume. Correlation between the two methods is not simple. Michalec however, developed equations, which resulted in easy-to-use tables. See:

Now . . . Tolerances for Over-Pin Measurements, May '57, p 194.

smart design plans . . .

MORE FUNCTIONS FOR SINGLE PART

It's the author's version of multiplexing. It means designing the part to do several jobs simultaneously. Here are several ways to use this proven design technique.

PAUL S AMBER,
consulting engineer
Amber & Amber, Detroit

■ You can't serve more than one master but machine elements can—and do it all the time. Consider a household water pipe. Its main job is to carry water but it also serves as a beam to support the water meter and as an electrical conductor (110 v ground). A clever designer might also use it as a structural support for a wall—or as a tiepoint for the basement clothesline.

This is multiplexing, the designer's technique for combining the functions of two or more separate parts. Others might call it value engineering. The goal is the same: to reduce cost and complexity, without sacrificing performance.

Multiplexing, then, is just a new name for an old idea. But making each element of the design work as hard as possible has special significance for today's complex products. The more complex the design, the more opportunity for multiplexing . . . and the more reason to simplify. When each of the functions of supporting, conducting, enclosing, driving, rotating, insulating, etc, are combined in one package, you will discover many ways to double up.

Here are some modern examples:

- The joints in structural compartments of airplane wings and ship hulls are sealed so the compartments also serve as fuel tanks.
- A gas-carrying pipe is made to act as speaking tube by adding a diaphragm to each end.
- A heat pump combines the duties of a furnace and an air conditioner.
- Reinforcement rods in concrete floors are used as elements for electric radiant heating.

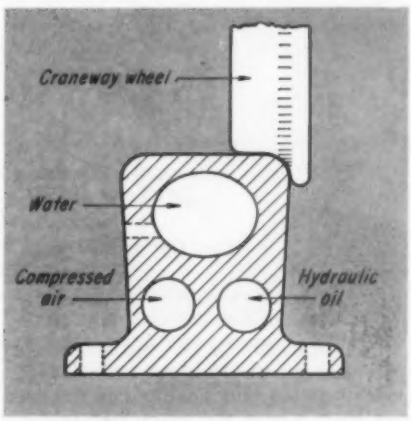
And here are some possibilities for the future:

- Transcontinental oil and gas pipelines to serve as an ultrahigh-frequency waveguide.
- A machine-tool frame made of pipe to carry cutting fluid and electric power for drive motors.
- An automobile spare tire to carry part of the springing load.
- Metal lath in plaster walls, to conduct electricity for radiant heating.

From these examples it is clear that multiplexing is a process of synthesizing—making a new pattern from what is already at hand. Rather than a strict engineering science, it is an art and demands a high level of creative imagination if your multiplexed products are to be stable and mature.

When to multiplex

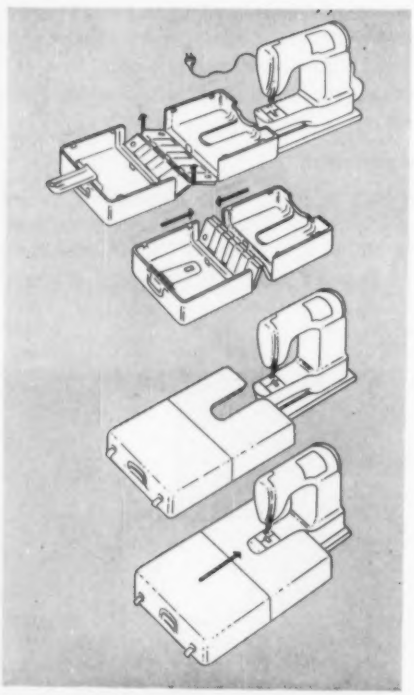
"If you have a lemon, make lemonade," directs an old proverb. Making the lemonade is always the first step in design and the most important. Only after the product has passed through these initial design stages can you



SIX JOBS IN ONE are handled by this extruded aluminum craneway rail. Besides its primary function it is also a structural beam in the building, a conductor for electric power, and piping for water, hydraulic oil and compressed air.

SECONDARY FUNCTIONS FOR THESE COMMON MACHINE ELEMENTS

FUNCTIONAL ELEMENT	EXAMPLES	PRIMARY FUNCTION	SECONDARY FUNCTIONS
Conductor	wire, bus bar, cable, ribbon	conduct electric current	tie, shaft, conduit, heater, beam
Insulator	electrical, thermal, sound barrier	resist conduction of heat, electricity, sound	finish, fastener, enclosure
Beam	truss, cantilever, girder, lever	withstand transverse load	shaft, conductor, tie, column, pivot, conduit, tank, track
Column	strut, stanchion, legs, pillar, frame	withstand axial load	conductor, conduit, track, pivot
Tie	chain, link, belt, rope, sling	withstand load in tension	conductor, shaft, pivot, joint
Plate	desk, table, cover, hatch, partition, bulkhead	cover an open area	insulator, conductor, enclosure, tank
Pivot	hinge, bearing, slide, gear	permit limited rotary movement	fastener, drive, tie
Shaft	rod, tube	transmit rotation	beam, tie, conductor, column, conduit
Drive	gear, pulley, friction	couple rotational elements	pivot, joint, fastening
Motor	electric, gasoline, spring, gravity	provide power	heat source, gyroscopic stabilizer
Finish	plating, paint, embossing	improve appearance, reduce deterioration	conductor or insulator for heat or electricity
Track	ways, grooves, rail, road	guide linear movement	conductor, beam, conduit
Conduit	pipe, duct, drain, tube, raceway	conduct fluids, particles, wires	tank, enclosure, beam, shaft
Enclosure	tank, housing, compartment, box	seal and protect machinery	beam, conductor, motor, column, conduit



MULTIPLEXED CARRYING CASE also serves as work surface for ELNA sewing machine. The only additions to the case are extra hinges and a special latch.

begin to consider multiplexing. At this point it has presumably achieved a consistently high level of performance and is ripe for squeezing out the pounds and dollars.

Like value engineering then, multiplexing follows design. In some cases, it may come even later, during redesign of a production model. Every designer enjoys the game of second-guessing his previous efforts. But be cautious: If you make too many changes at once you may unwittingly sacrifice performance for a small gain in simplicity.

When reviewing a design for opportunities to multiplex, consider the function of each part. What does it do and what else could it do? Use the chart on this page as a guide to suggest secondary functions for the part. It is important at this stage to consider only the function—as distinct from the means for accomplishing that function. The function of the wooden barrel of a lead pencil is to support the lead and provide a grip for the fingers. But it might also serve as a display area for advertising. The lead could make electrically conductive lines as well as visible marks. And the eraser might work as a phone-dialer if mounted in a holder of a different shape.

Look particularly for opportunities to combine mechanical and electrical functions. Here is where many opportunities lie. More and more, electrical and electronic devices are mounted in the same package with the mechanical elements. In future designs, structural components will carry electric current, and electrical components will also serve structural requirements. Moreover, there will be doubling up in the functions of electronic components—a single transducer signal will be used for several control purposes.

Besides combining existing functions, new ones can sometimes be added at no extra charge. Any new function that goes along for the ride is worth considering if

Can your design be improved by multiplexing?

Ask yourself these questions

1. What mechanical parts can also conduct electricity?
   Examples: Shafts, panels, reinforcements.
2. What electrical conductors can be used structurally or mechanically?
   Examples: Pipes, tracks, columns, beams.
3. What active elements can serve as chassis or housing?
   Examples: Magnetic core, printed circuit board, tank, panel.
4. What frame members can serve as fluid containers?
   Examples: Box frames, hulls, chassis.
5. What frame members can act as conduits for fluids and wires?
   Examples: Tubular frames, box frames.
6. What flat parts can serve as housings?
   Examples: Heat-exchanger panels, capacitors, rectifiers.
7. What physical properties of structural or mechanical members can be used to advantage?
   Examples: Optical, magnetic, thermal.
8. How can surface finish be made to serve an active function?
   Examples: Insulation, adhesive, emissive, protective.
9. Can waste heat be put to work?
   Examples: To power air conditioners, space heaters, preheaters.
10. What electronic properties of structural or mechanical parts can be used?
    Examples: Waveguide, capacity, magnetism, inductance.
11. What beam, column, or tie can also provide elasticity and damping?
    Example: Wood, laminated beams, concrete.
12. What other functions can the housing, panel, or enclosure serve?
    Examples: Display service information, instructions, advertising.
13. What new secondary functions can be added?
    Examples: Power outlet, advertising.

it serves a real purpose. For example, some small purchased parts are now being shipped in containers that accommodate the loading and feeding devices of the customer's automatic machinery.

But this kind of multiplexing can be carried too far. There's no point in adding a second function if it is not needed. Avoid the gadget that does many jobs, none of them well. The objective is not to produce the mechanical counterpart of the one-man band.

Can your present design benefit from multiplexing? Look over the questions in the checklist at top of this page. It will show where to look, and suggest design alternatives you might otherwise overlook. ■

EDITOR'S NOTE: When refining a new design or redesigning an existing product, consider also the cost saving factors presented in these recent articles:

Value . . . The Emerging Emphasis on Design, May 15 '61, p 79—A study of present and future potentialities of such specialists services as reliability, value analysis, value engineering and quality assurance.

Do Your Own Value Engineering, July 11 '60, p 61—How to apply the cost squeezing tricks without depending on the services of a value engineering group.

Producibility Check List, Dec. '55, p 174—When cost or weight is too high, these are the most probable offenders.

—Charles J Lynch

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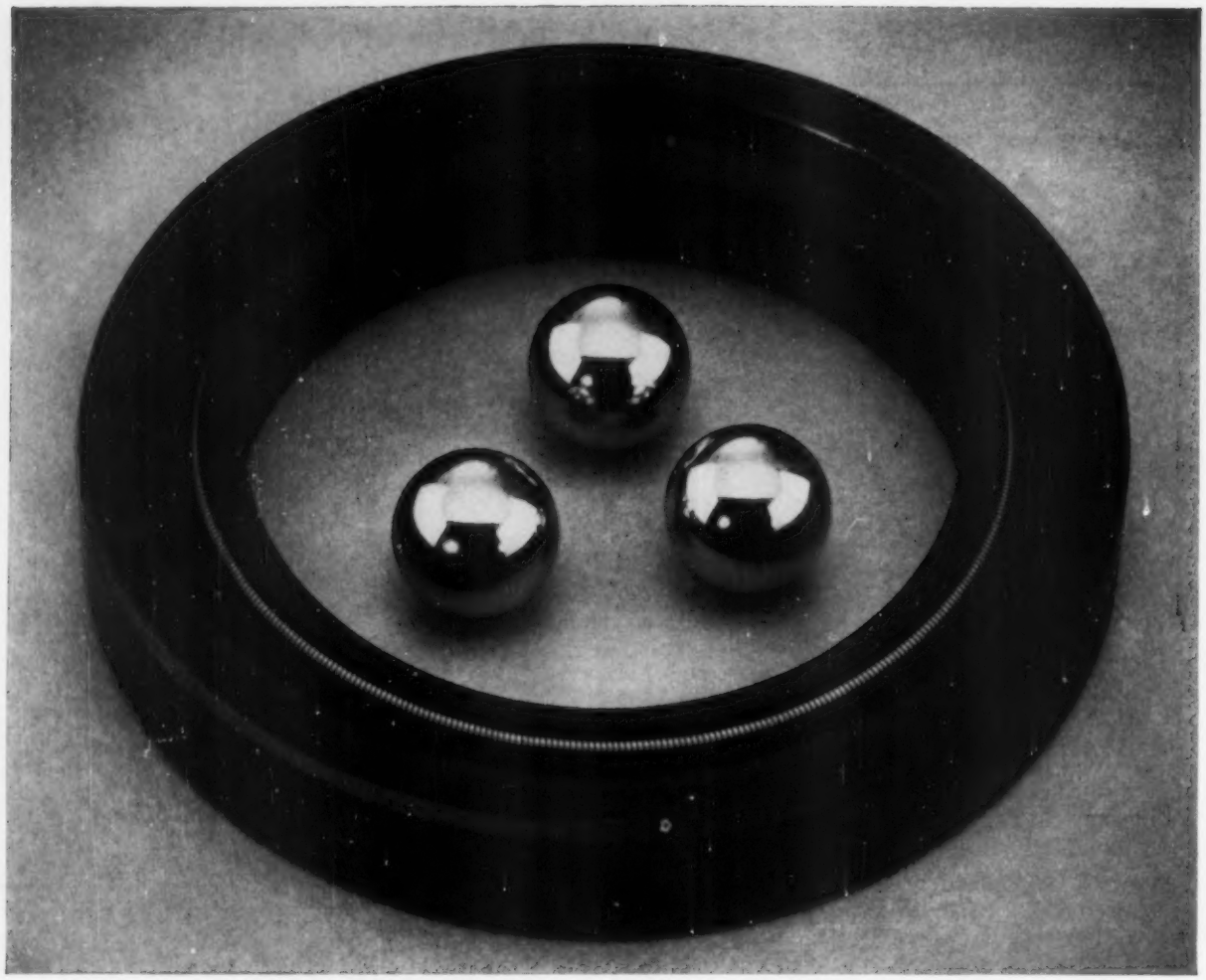

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J-M Clipper Seals protect better because each is specially compounded to do its specific job. When you install the *right* Clipper Seal for your service conditions, it keeps lubricant in, seals out damaging dirt and grit . . . resists heat, speed and corrosive chemicals . . . gives you long, efficient protection. Here are the reasons why you can count on Clipper Seals for better service:

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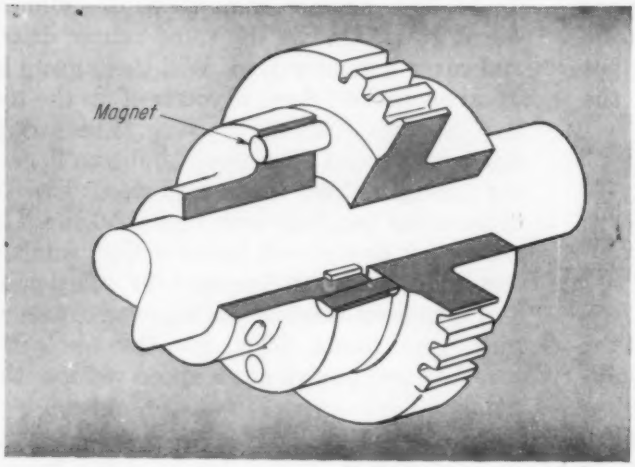
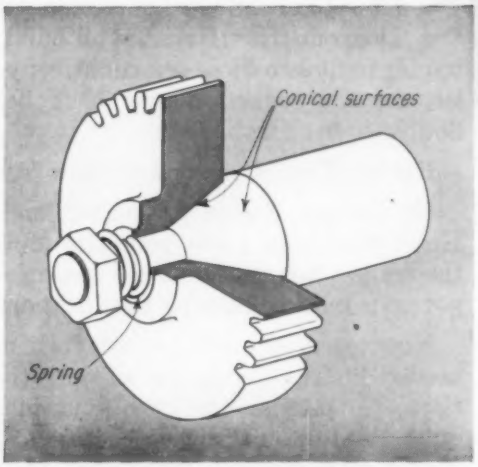
TORQUE-LIMITERS PROTECT LIGHT-DUTY DRIVES

In such drives the light parts break easily when overloaded. These eight devices disconnect them from dangerous torque surges.

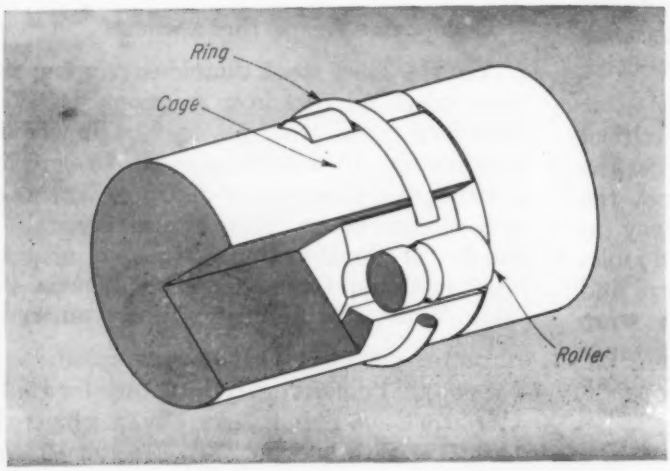
L KASPER,
design consultant
Philadelphia



1
MAGNETS transmit torque according to their number and size. In-place control is limited to lowering torque capacity by removing magnets.



2
CONE CLUTCH is formed by mating taper on shaft to beveled hole through gear. Tightening down on nut increases torque capacity.

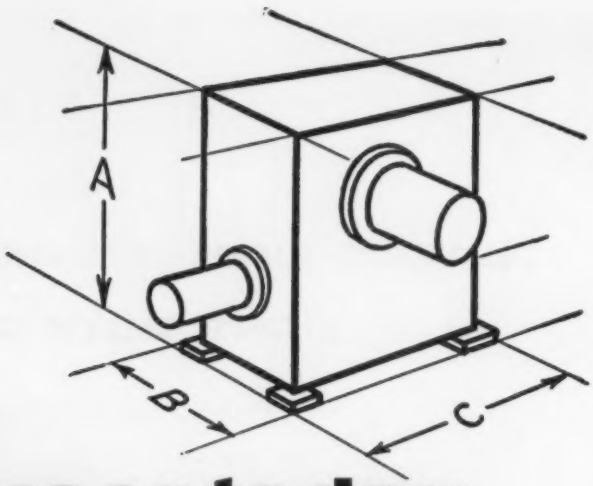


3
RING fights natural tendency of rollers to jump out of grooves cut in reduced end of one shaft. Slotted end of hollow shaft is like a cage.

continued on page 81

Advertisement

Do-It-Yourself...



Let's design a speed reducer today

So you can't find a speed reducer to fit your latest brainchild without ruining the design? Doggone manufacturers all build reducers too big to fit into those few cubic feet you've got left for the reduction unit back behind the double-ended dingbat?

Revolt! Design your own! Show 'em!

By George, design it yourself and it'll fit. How? Well, you know your size limits. Draw the biggest box that'll fit the space and you've got your reducer housing specifications.

Now you need gears that will (1) transmit the needed horsepower under all operating conditions, (2) provide the ratio your machine requires and (3) fit the space that's available. You'll soon discover that there are limits to what gears can do in transmitting horsepower. The cheapest answer is parallel shaft helical gears. If they'll fit you're in clover. But they take the most room, especially when you're out of the fractional hp range. The right angle worm and gear combination is the most compact drive arrangement.

Here again you have a choice. Cylindrical worm gearing is often used, and if it'll do the job, is worth consideration. But it's not the most compact possibility. The best way to shrink gears and still carry the load is the double-enveloping worm gear design. Both worm and gear are throated and the two literally wrap around each other. This brings center distance of the two shafts closer together and you can put them inside smaller housings.

Does this reduce load capacity? No sir! You can carry the same load with center distances up to 33% smaller than those of cylindrical worm gears. Or use the same center distance and carry a greater load. Will these gears hold up in operation? Sure, if you beef up the teeth, the bearings and the housing. Use straight-sided worm and gear teeth and you'll get all the strength there you'll ever need. Use large taper roller bearings with real B-10 life. Use a reinforced, heavy wall housing that won't distort under load. Put fins on it for added cooling and increased thermal horsepower capacity to meet your needs. Now, put the whole thing together and you've got a speed reducer that's a dilly.

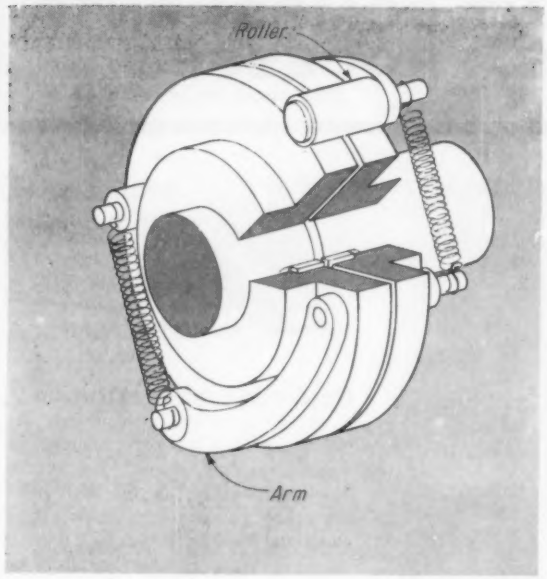
Designing your own speed reducer give you a headache? Looking for an easier way? There is one. Someone's already done exactly what you're talking about. You can order that compact speed reducer right off the shelf. Where?

Cone-Drive Gears, that's where!

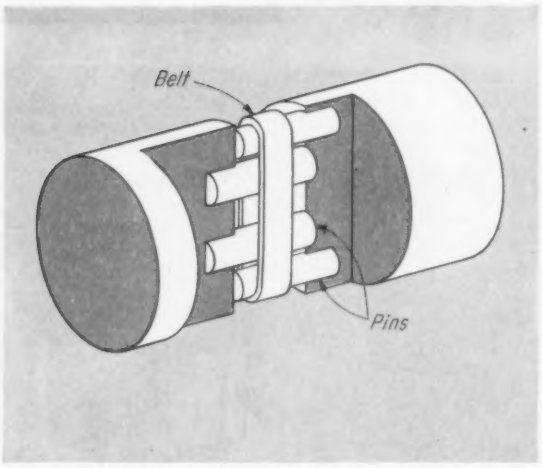
Yes sir. They stock double-enveloping worm gear speed reducers from fractional to 665 hp. Standard ratios from 5:1 to 70:1 in about 15 increments, all interchangeable in any type housing of a given center distance. Worms over and worms under. Gear shafts vertical, too. Single- or double-extended output shafts, or shaft mounted. Over 200,000 combinations possible. Wow! Just about anything you want.

Better get Cone-Drive's new speed reducer catalog that details everything. Ask for Bulletin CD-218. Cone-Drive Gears, Div. Michigan Tool Co., 7171 E. McNichols Rd., Detroit 12, Mich.

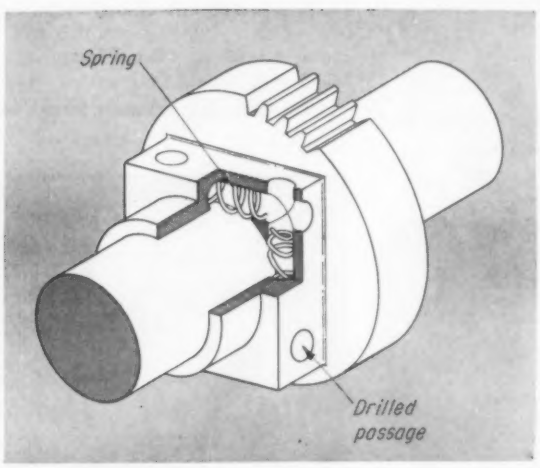
TORQUE LIMITERS continued



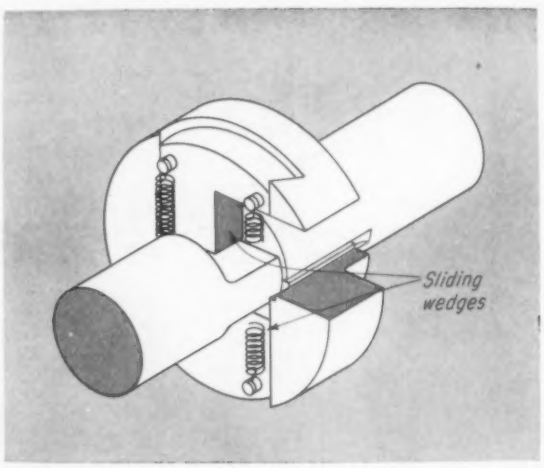
4
ARMS hold rollers in slots which are cut across disks mounted on ends of butting shafts. Springs keep rollers in slots; over-torque forces them out.



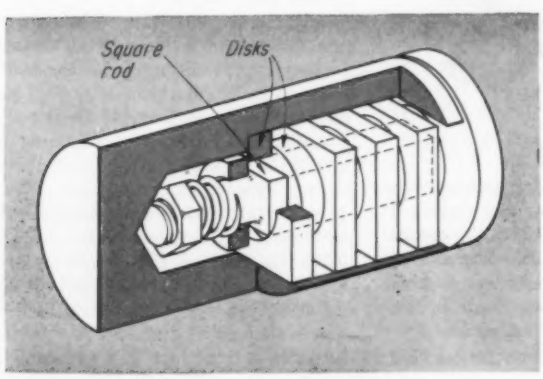
5
FLEXIBLE BELT wrapped around four pins transmits only lightest loads. Outer pins are smaller than inner pins to ensure contact.



6
SPRINGS inside drilled block grip the shaft because they distort during mounting of gear.

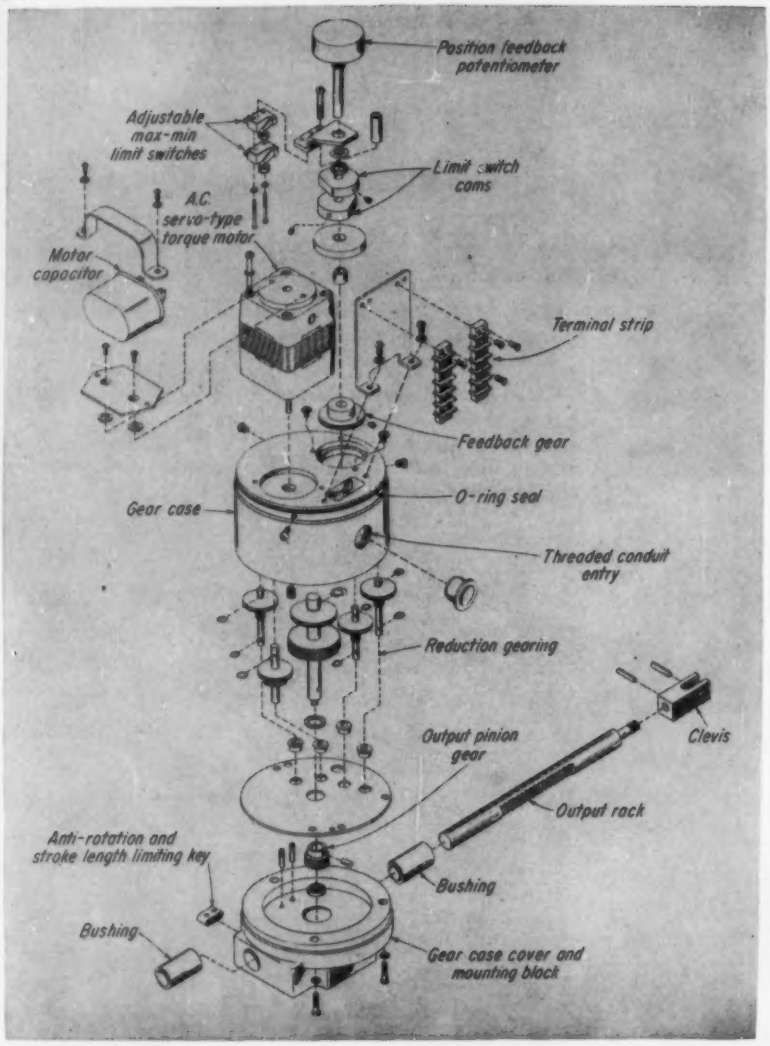


7
SLIDING WEDGES clamp down on flattened end of shaft; spread apart when torque gets too high. Strength of springs which hold wedges together sets torque limit.

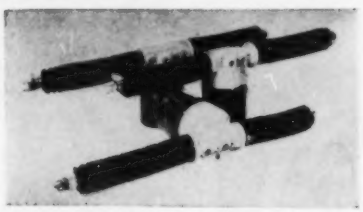


8
FRICTION DISKS are compressed by adjustable spring. Square disks lock into square hole in left shaft; round ones lock onto square rod on right shaft.

SIGNIFICANT COMPONENTS MATERIALS, PROCESSES



Linear actuator . . .
provides linear positioning in proportional response to a control signal from a dial, clip-card, punched tape or other input. Small ac torquemotor drives into a 2- to 6-stage spur gear reduction, and output of gear train is converted into a linear motion by rack and pinion. Unit is compatible with control systems using low level dc signals or 3 to 15 psi. It positions machine tools, gates, slides or valves; controls rate, load, tension level or proportion. Can have built-in feedback potentiometer and limit switches for remote indication or to serve in control circuits. Available in two types; four models that provide stroke control from 1½ to 30 in. Thrust

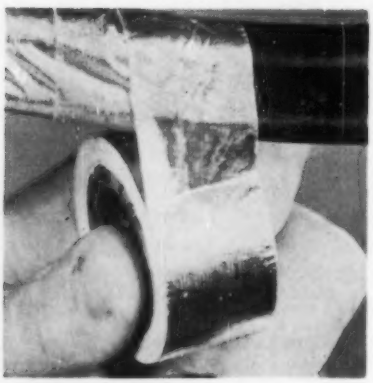


capacities are up to 300 lbs; stroking rates from 5½ to 240 in. per min. Standard accuracies are 1 part in 1000, but special "coarse-fine" units provide resolutions to 1 part in 30,000. Prices range from $224.25 to $453. **Jordan Controls Inc, 3235 W Hampton Ave, Milwaukee 9.**

Circle 300 on Reader Service Card

Hard-soft rubber extrusion . . .
is one-piece extrusion combining longitudinal sections of two different hardnesses (typical is 60 and 90 durometers). Seals incorporating the extrusion use the soft rubber to meet actual sealing requirements and the hard rubber foot for simple mounting to an adjoining surface. Available in color combinations, the seals are extruded in pairs for max economy. Mating edges of the facing base or foot sections are beveled, leaving only a thin connection so that the two hard-soft strips can be separated without tools. Sizes range from ¼ to 1¾ in. Samples delivered in approx 4 to 6 wk. **Geauga Industries Co, Middlefield, Ohio.**

Circle 301 on Reader Service Card



Reflective tape . . .
shields motors, wires and delicate structural parts from extreme heat. Performs continuously at temps of 500 to 600 F and withstands more than 3000 F of radiant heat for short periods. Described as a lamination of 0.0005-in. aluminum foil to 0.002-in. glass cloth coated with a white silicone adhesive, the tape is said to be so durable that it can be spiral-wrapped with no damage to reflectance. Its caliper is 0.006 in., making tape conformable to irregular shapes and curved pipe. Weighing 0.0038 lb per ft/in. of width, it has tensile strength of 75 lb per in. of width. Intensity of heat tape will withstand de-

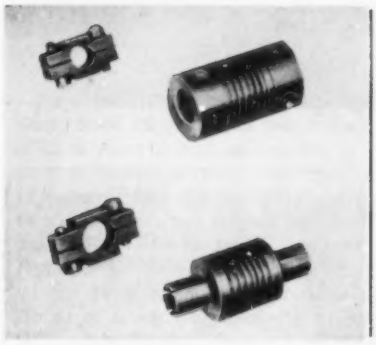
pends on type of heat involved—conductive, convective or radiated. Available in widths of from ¼ to 36 in. and in roll lengths of 36 yd. **Minnesota Mining & Mfg Co, Dept J1-1, 900 Bush Ave, St Paul 6, Minn.**

Circle 302 on Reader Service Card

Ablative coating . . .

priced substantially lower than comparable coatings, withstands temps in excess of 2000 F for more than an hr, while temp on protected surface remains under 350 F. Can withstand up to 6000 F for shorter durations. When flames reach coated surface—after completion of 24-hr cure at room temp—components of the coating bubble, swell and form a protective and thermally insulating barrier. After coating has served its purpose, can be washed off, leaving surface clean and free of any remnant of heat or flame damage. Priced at $30 per gal., which covers 960 sq ft, 1 mil thick. **Columbia Technical Corp, 24-30 Brooklyn-Queens Expressway West, Woodside 77, NY.**

Circle 303 on Reader Service Card



Miniature bellows couplings . . .

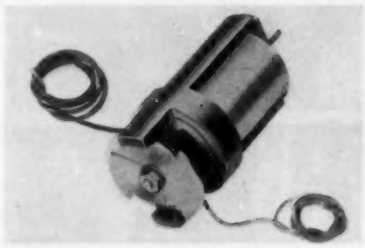
include solid, slit-hub and solid/split-hub combination types that are externally palladium flash-plated. Have phosphor bronze bellows and hubs; induction soldered construction; zero backlash; 5° angular misalignment; 3000-rpm max speed; and 200 in.-oz max torque transmission. Wide range of shaft diameters available in all types. From stock. **FAE Instrument Corp, 16 Norden Lane, Huntington Station, LI, NY.**

Circle 304 on Reader Service Card

Miniature slow-speed drive . . .

is basically a drive motor with a miniature gearless speed reducer and is suitable for such light-duty applications as potentiometers, slip rings and synchros. Reportedly not a substitute for conventional gearhead motors because of backlash and limited torque output, but offers smooth operation, high shock capacity under vibration (20 g's at 10 to 2500 cps), double or single ended output and compactness. Unit is made to order with size 10, 11 or 12 motor. Available input-to-output speed ratios range from 25:1 to 5000:1. Electrical characteristics depend upon requirements. Priced from $150 to $200 with delivery in 3 to 5 months, depending upon specifications. **Barden Corp, Danbury, Conn.**

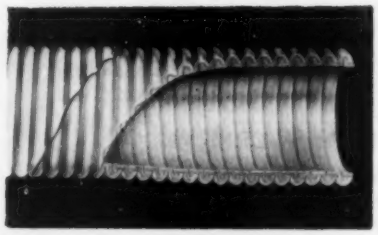
Circle 305 on Reader Service Card



Rotary solenoid . . .

requires only approx 0.0033-amp input current at room temp and 0.005 amp max at 29 v dc at −67 F. Torque at 203 F is 0.005 oz-in. min. Voltage range is from 25 to 29 v dc. Suitable to operate flags in indicators to MIL-1-22075 and for other rotary motion applications requiring low input and 35° total rotation. Delivery within 60 days. **John Oster Mfg Co, Avionic Div, Racine, Wis.**

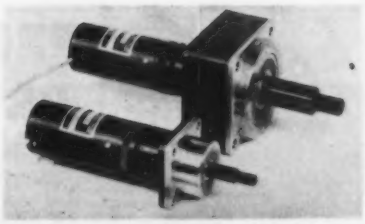
Circle 306 on Reader Service Card



Polyethylene tubing . . .

originally designed for swimming pool maintenance equipment and vacuum cleaners, is extruded by a one-piece bonded interlocked spiral which provides max structural support without wires. Also permits flexing to any radius without kinking or collapsing. Carries liquids from 32 to 150 F under full vacuum and withstands pressure of 25 psi under pumping conditions or from external sources. Interior is smooth for fast, easy passage of liquids and gases. Available in 1½ or 2 in. dia, but can be made to specifications of any length, diameter and color. Also can be furnished with vinyl cover for added resistance against abrasion in special applications. **Plastiflex Co, 1038 Princeton Dr, Venice, Calif.**

Circle 307 on Reader Service Card



1½-in. gearmotor . . .

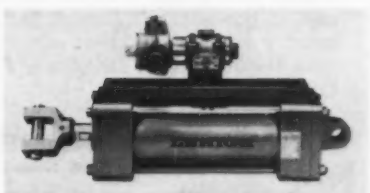
with planetary gearing system, provides up to 500 in.-lb torque at 8 rpm continuous duty and up to 1000 in.-lb torque for intermittent use. Ball bearings at all bearing locations provide stage efficiencies of 95% or better. Gearbox rating is ⅓₀ hp. System offers choice of 18 reduction ratios from 1.87:1 to 941:1. Ten ratios from 219:1 to 5211:1 are available for use with 3-in.-sq mounting flange. **Globe Industries Inc, 1784 Stanley Ave, Dayton 4, Ohio.**

Circle 308 on Reader Service Card

Time switch . . .

replaces two or more reset timers or manual switching for short duration operations. The multiple dial control is suitable for use wherever operations of from a second through several minutes may be needed every hour, every few hours or every few days. Minimum settings are from ON 1 sec in 7 days through 55 min. every hour of the day, every day. Programs can be changed by resetting tabs or trippers, or operation can be eliminated automatically on Saturday, Sunday, holidays or any preselected days of the week. Available models include one that provides settings in 1-sec increments and another that provides settings in 1-min. increments with a minimum setting of two min. Manual switch is built-in for use in controlling operations at times other than as programmed without disturbing master cycle. **Industrial Controls Div, Tork Time Controls Inc, Mt Vernon, NY.**

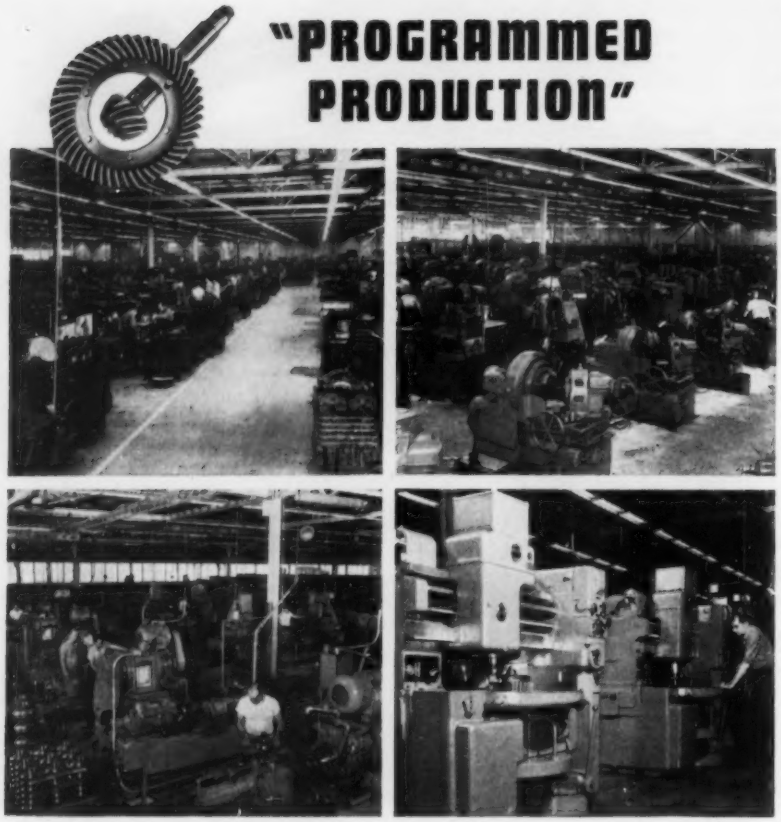
Circle 309 on Reader Service Card



Air motor . . .

has integral valve-on-cylinder arrangement, seating valve directly on a manifold which is a solid fixture to the heads. This eliminates need for air transfer tube and produces faster response than is possible with motors whose valves are located at a distance from their cylinders. Contrasted with in-line type motors, which position

continued on page 84



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AT **FAIRFIELD**

benefits users of gears

Simple arithmetic explains why, TODAY, many of America's leading machine makers no longer undertake to solve the problems involved in production of gears, differentials, and specially designed gear parts. For them, FAIRFIELD IS THE ANSWER!

Every facility is available at Fairfield—latest, cost-cutting, ultra-modern metalworking and heat treating equipment, kept busy by volume production, *plus* expert engineering counsel. This makes for ECONOMY and EFFICIENCY that can BENEFIT YOU.

Check with Fairfield NOW on your gear production schedules. As one of the nation's largest independent producers, Fairfield can usually give you quickest service available and handle any production requirement. *Become a Fairfield customer; it pays!* CALL OR WRITE.

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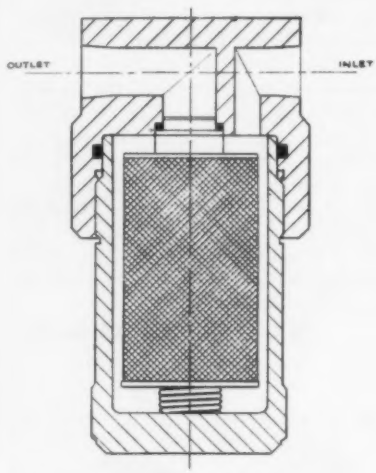
Gears and Differentials for FINE GEARS *Made to Order for:*

TRACTORS • HEAVY DUTY TRUCKS • AGRICULTURAL MACHINERY • POWER SHOVELS AND CRANES
MINING MACHINES • ROAD GRADERS • BUSES • STREET SWEEPERS • INDUSTRIAL LIFT TRUCKS

valve at one end of cylinder, unit requires less linear operating space and frees both ends of cylinder for use. Has double-acting, self-lubricating air cylinder and is available with single, double solenoids, momentary and maintained constant, and in 1½-, 2-, 3- and 4-in. dia sizes (larger diameters on request). **Air Control Div, Lehigh Inc, Easton, Penna.**

Circle 310 on Reader Service Card



High-pressure microfilter . . . has offset port that is said to boost capacity in average size unit as much as 25% (in large unit, gain reportedly is even greater). Operates at pressures up to 10,000 psi and removes particles from 100 to 2 microns. Offset of the outlet port (eccentric with the cylindrical element) also is said to prolong element life by allowing top flange of element to be designed as a conical "splash" plate. This dispenses fluid more evenly around element, prevents local overloading and aids settling of large particles in bowl. Body and head are produced in all standard corrosion-resisting materials for all standard connections. Element can be either depth or surface type and is made of stainless steel. **Fluid Dynamics Inc, Dept P-1, 90 West St, New York 6.**

Circle 311 on Reader Service Card

Transient protector for diodes is ⅜-in. dia x 1⅜-in. control device that protects low cost (200 PIV) silicon and germanium diode rectifiers from excessive peak inverse voltages. Available as an individual component or built into a packaged full-wave rectifier with max input of 130 v ac and max output of 118 v dc. With the transient control device, it is reportedly possible to use $0.60 silicon diodes and obtain reliability provided by

continued on page 86

Aeroquip Introduces New Low-Cost Reusable Fitting for High Pressure Hose Lines

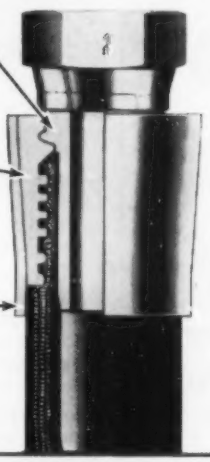
How IRON MIKE Fitting Grips Hose

NIPPLE
Designed to fit into hose without cutting inner tube. Available in 10 end fitting styles.

SEGMENTS
Grip hose reinforcement securely, mate with nipple assembly for correct positioning.

SOCKET
Forced over segments during assembly to form a rugged compression fitting that won't blow off.

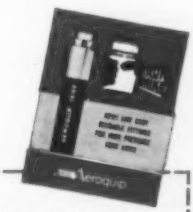
PATENT APPLIED FOR



Meet IRON MIKE, a rugged new hose fitting that provides all the field service advantages and replacement economy of reusable fittings—at rock-bottom prices. Hose assemblies made with IRON MIKE Reusable Fittings compare in cost with assemblies made with non-reusable fittings. Design is so simple that foolproof assemblies can be made by factory or service personnel in minutes.

IRON MIKE Fittings have been field tested for more than a year to assure traditional Aeroquip performance and dependability. Used with Aeroquip 1509 Multiple Wire Braid Hose, they are recommended for all industrial high pressure hydraulic applications up to 2250 psi. as well as pneumatic, fuel and lubrication systems. IRON MIKE Fittings are available in ten standard end styles for hose sizes from ¾" to 2" I.D.

Mail coupon below for new Aeroquip Bulletin No. 651.



Aeroquip

AEROQUIP CORPORATION, JACKSON, MICHIGAN

Aeroquip Corporation, Jackson, Michigan PE-7
Please send me Bulletin No. 651 on new IRON MIKE Fittings and 1509 Hose.

Name_____
Title_____
Company_____
Address_____
City_____ Zone_____ State_____

LET MUELLER MAKE IT!

Mueller Brass Co. of Port Huron is much more diversified than the name "Brass" implies . . . a lot more. In fact, because of its many and varied facilities . . . its *men, methods* and *metals* . . . Mueller is in the unique position of being able to offer true single source service.

MUELLER HAS THE MEN . . . experienced engineers with the ability to work out, creatively, tough design problems, and improve a part or components for production by the most economical method. You get sound engineering plus 44 years of practical metalworking production experience when you "Let Mueller Make It."

MUELLER HAS THE METHODS . . . when you "Let Mueller Make It", you are utilizing one single source that is able to produce parts any one of these ways: as forgings, impact extrusions, sintered metal parts, screw machine products, formed tube or as castings.

MUELLER HAS THE METALS . . . and the materials . . . to produce precision parts in aluminum, brass, bronze, copper, iron, and steel in hundreds of different alloys to meet each exact requirement.

In addition, Mueller Brass Co. has complete and modern facilities for performing all types of finishing and sub-assembly operations. Another plus value is nation-wide sales engineering service.

So, in the final analysis, no matter where you fit in the American industrial picture, whether you're making missiles or mowers . . . and no matter where you're located, it will pay you to LET MUELLER MAKE IT!

MUELLER BRASS CO.
PORT HURON 29, MICHIGAN

high PIV silicon diodes costing $5 and more. Comprising device are gas tubes which ionize when a critical voltage is reached, creating a low resistance shunt for transients that would otherwise destroy diodes. Operates by shorting all voltage above control point, automatically preventing transient voltage from exceeding rating of a 200-PIV diode. Unit protects against transients originating on both ac and dc sides. Rated at approx 200 v (higher and lower rated protectors will be custom made) and is recommended for protection wherever silicon or germanium diodes share a circuit with inductive loads. Prototype models of both transient control and rectifier with built-in control are from stock. Transient controls are supplied in boxes of 10, with one box priced at $20.50; 2-9 boxes, $18.50 per box; and 10-49 boxes, $16 per box. Protected rectifier is priced at $8.15 each in quantities of 1-9; $7.40 each in quantities of 10-24; and $6.80 each in quantities of 25-99. Kit, containing a protected rectifier and extra transient control, is priced at $11. **Ledex Inc, 123 Webster St, Dayton, Ohio.**

Circle 312 on Reader Service Card

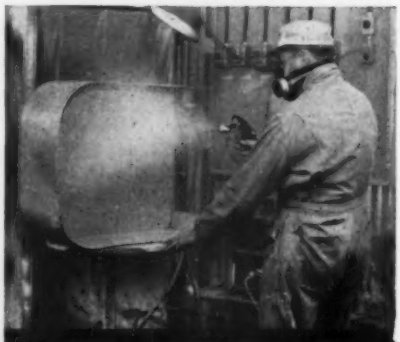
Pillow blocks . . .
are equipped with self-aligning, single row, deep-groove, precision ball bearings. Weigh from 2.2 to 98 lbs and are said to have dimensional interchangeability with other makes. Available in 31 shaft diameters from $\frac{3}{8}$ to 4 in. for shaft speeds from 8500 to 2000 rpm. **Link-Belt Co, Dept PR, Prudential Plaza, Chicago 1.**

Circle 313 on Reader Service Card

Vibration-insensitive transducer . . .
is miniature, low pressure potentiometer unit, said to have less than 1% error at vibration levels of more than 35 g's. Available in 0-10 and 0-350 psi absolute or gage pressure ranges, it operates on new pressure sensing principle. Two separate sets of aneroid capsules are mounted at opposite ends of a driving frame. One set

continued on page 88

big savings for your finishing department



A PICTURE OF WASTED PAINT. The overspray you see is typical of most old-fashioned spray systems. Fifty per cent or more of the paint never reaches the object to be painted at all.

WITH NORDSON AIRLESS. The same product being sprayed by the same man; but, this time, little or no overspray — paint waste cut 25 per cent or more.

With an ordinary spray system, 600 parts of air are needed to atomize one part of paint. When the spray gun is triggered, the mass of air must go somewhere and it carries with it clouds of paint — much of which goes up the spray booth exhaust stack or settles where it is unwanted.

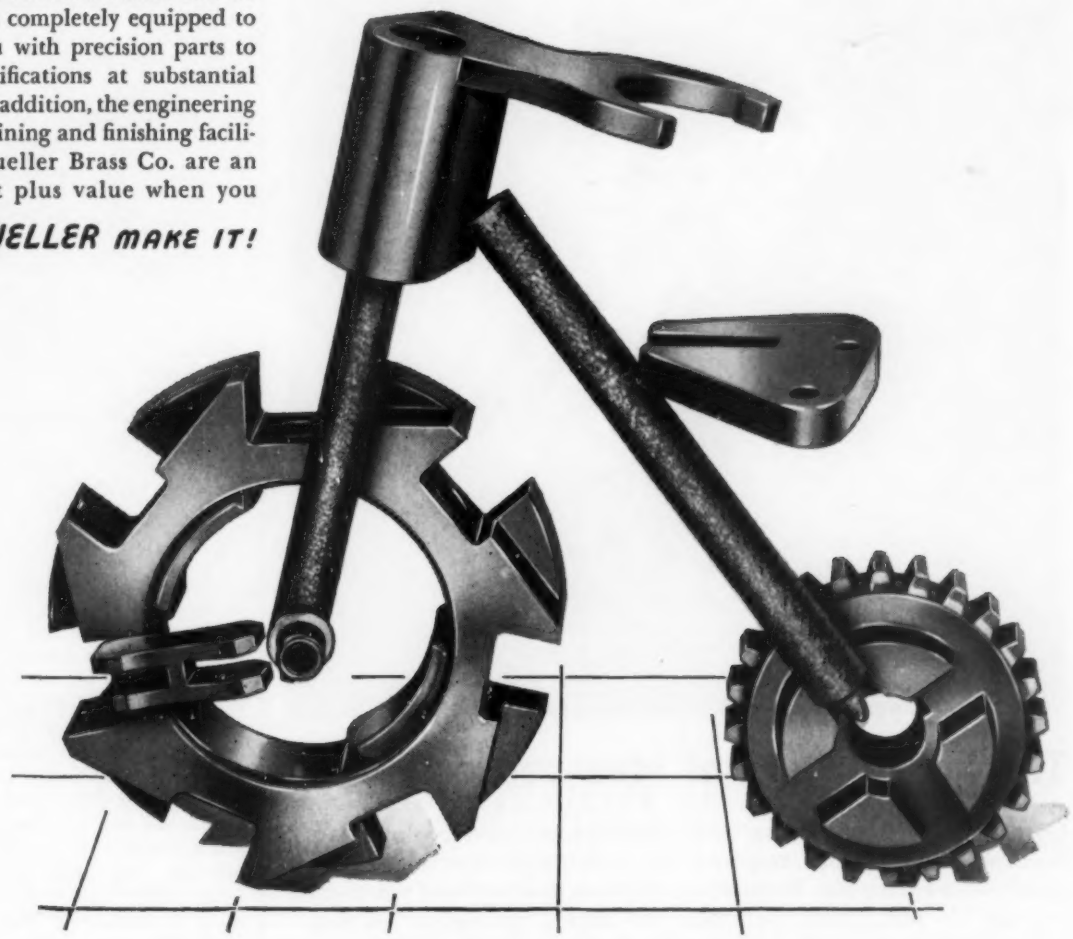
The Nordson Hot Airless System changes all that. *No* air is used for atomization so overspray is cut to a bare minimum. Important savings are made in both material and labor. Clean-up time is cut to the bone, housekeeping improved. We can show you how to cut painting costs and at the same time get better finish quality. Write for your free copy of the Nordson Hot Airless Spray Brochure.

NORDSON CORPORATION
86 JACKSON STREET • AMHERST, OHIO

MUELLER CAN MAKE MOST ANYTHING IN SINTERED METAL PRODUCTS...

Sintered metal gears, cams, special purpose filters and structural members from iron, nickel, stainless steel, brass and copper alloys are produced by Mueller for practically every segment of American industry. Whatever your product requirements are, the Mueller Sintered Metal Products Division is completely equipped to supply you with precision parts to exact specifications at substantial savings. In addition, the engineering staff, machining and finishing facilities of Mueller Brass Co. are an important plus value when you

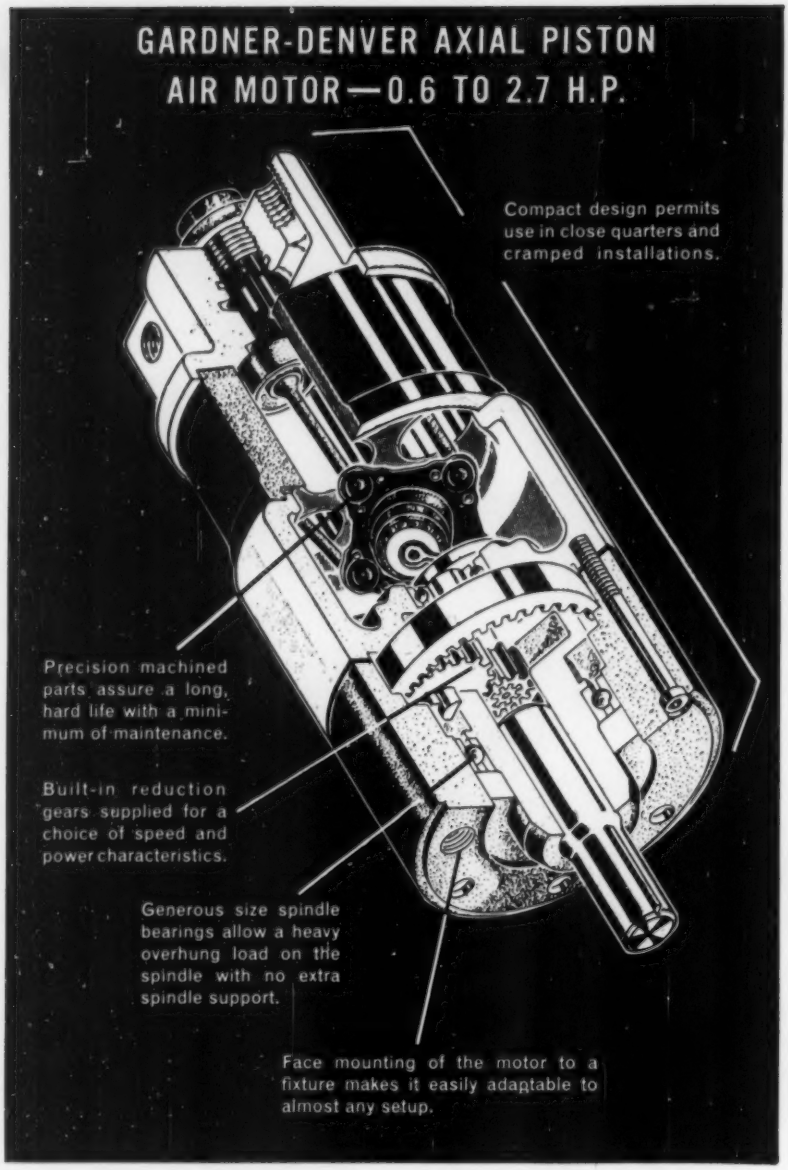
LET MUELLER MAKE IT!



MUELLER BRASS CO.
PORT HURON 29, MICHIGAN

CIRCLE 87 ON READER SERVICE CARD 87

GARDNER-DENVER AXIAL PISTON AIR MOTOR—0.6 TO 2.7 H.P.


Compact design permits use in close quarters and cramped installations.
Precision machined parts assure a long, hard life with a minimum of maintenance.
Built-in reduction gears supplied for a choice of speed and power characteristics.
Generous size spindle bearings allow a heavy overhung load on the spindle with no extra spindle support.
Face mounting of the motor to a fixture makes it easily adaptable to almost any setup.

The Inside Story of idea-packed power

Gardner-Denver air motors offer variable-speed power control . . . positive, instantaneous response and continuous operation. Won't spark—can't burn out. Remember, wherever the products you design are put to work, your customers will find a convenient Gardner-Denver office with ample parts stock on hand, and manned by factory-trained service specialists. For details, call your Gardner-Denver air power specialist, or write for air motor bulletins.

EQUIPMENT TODAY FOR THE CHALLENGE OF TOMORROW

GARDNER-DENVER Since 1859

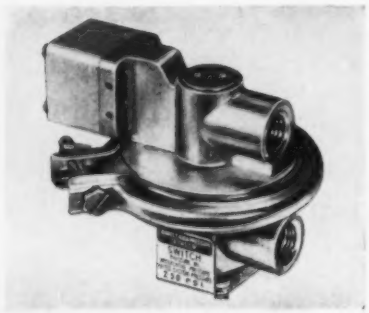
GARDNER DENVER

Gardner-Denver Company, Quincy, Illinois

In Canada: Gardner-Denver Company (Canada), Ltd., 14 Curity Avenue, Toronto 16, Ontario

is connected to inlet pressure fitting, while other is either evacuated for absolute pressure reference or vented to atmosphere for gage measurement. Pressure change is transmitted as proportional linear movement through a metallic belt linkage to wiper of potentiometer. Pressure media and gage reference pressures are contained within aneroid capsules and therefore isolated from electrical component, enabling operation in an deleterious atmosphere without adverse effect. Weighs 4 oz and measures 1 in. dia x 2 in. long. **Servonic Instruments Inc, 1644 Whittier Ave, Costa Mesa, Calif.**

Circle 314 on Reader Service Card



Sensitive electrical switches . . .

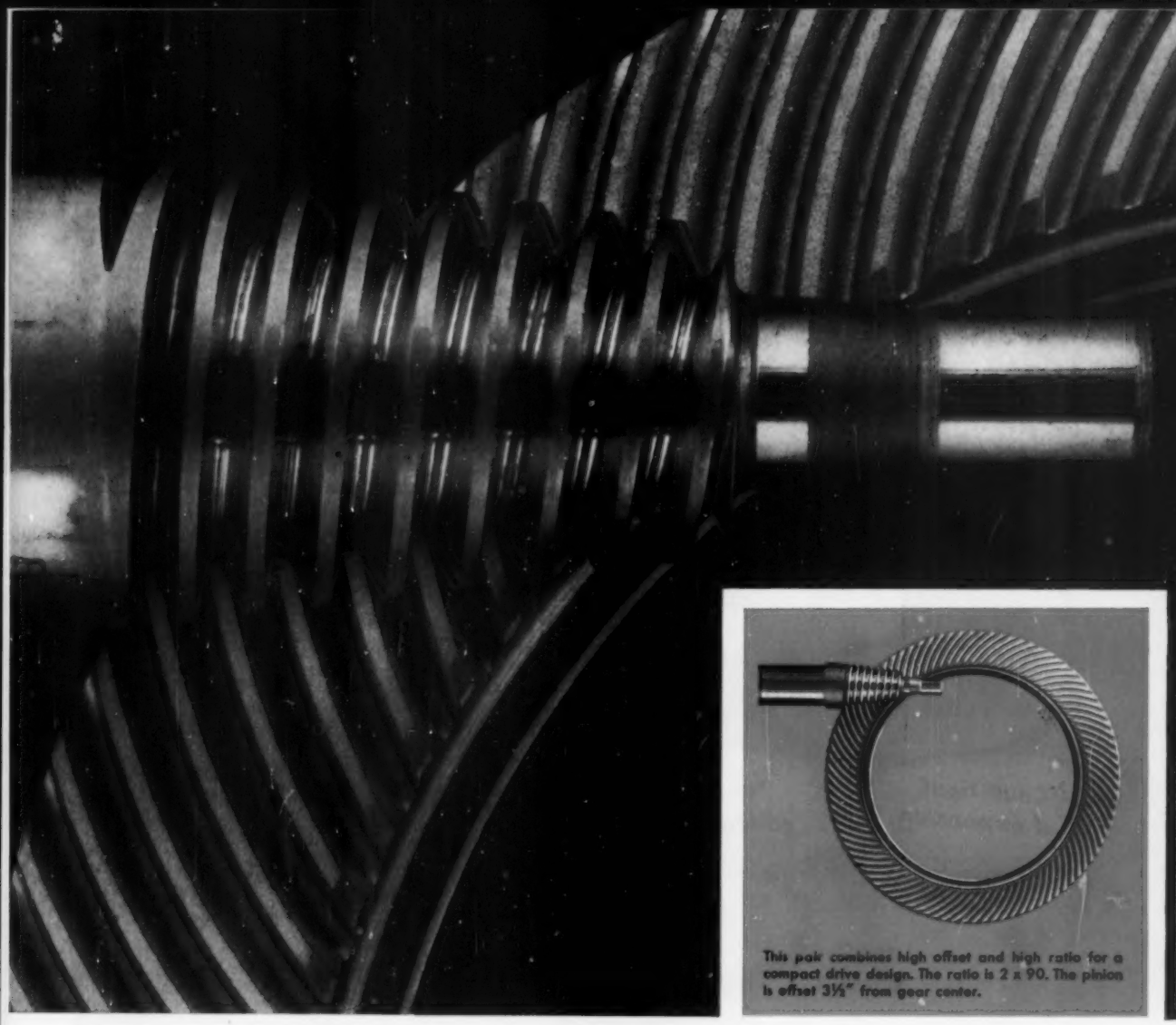
signal pressures and differential pressures in the low range of 0.25 to 16 in. of water column. Operate by means of spring-biased diaphragm, which senses very low pressures and at a preselected point actuates a rod, which in turn sets off a switch mechanism. Desired actuation pressure is set by a direct reading dial. Contain no mechanical linkages and are immune to damage from overpressure up to rated capacity of 250 psi. When used as differential pressure switches, actuation of units is completely independent of absolute working pressure (switch set to actuate at 0.4 psi differential, or 11 in. of water column, will do so with 0.4 psi upstream and zero psi downstream and is said to function equally well with 250 psi upstream and 249.6 psi downstream. Units measure approx 2 x 3 in. and are made of aluminum. **Pall Corp, Glen Cove, NY.**

Circle 315 on Reader Service Card

Sprag-type clutches . . .

available in two models, index at rates up to 5000 cycles per min., or 15% more than other models. Separately contoured, individual leaf springs provide individual control of sprag energizing, enabling units to meet over-running and indexing requirements of miniature mechanisms. One model provides 4.5 ft-lb torque and is

continued on page 91



This pair combines high offset and high ratio for a compact drive design. The ratio is 2 x 90. The pinion is offset 3½" from gear center.

See how the teeth "wrap around" this high-reduction pinion

This is a high-ratio hypoid gear. In principle, it is not different from more conventional hypoids produced by the Gleason Works. *But . . .*

If you look closely at the pinion, you'll notice that the teeth tend to "wrap around" it. This design is extremely well suited for high reduction, strength and compact design.

The result is a conical (or sometimes cylindrical) pinion which permits *continuous tooth action—even with just one or two teeth!* Compared to corresponding bevel pinions, its diameter is greater for higher strength. An extended shank on cylindrical pinions makes *very rigid* straddle mountings practical.

You can design a *compact* unit, because high offset is possible! For high-offset *or* high-ratio pairs, the "wrap around" tooth design provides an extra measure of the smooth, quiet tooth action of hypoid gears.

High-ratio hypoids can be cut on the same Gleason equipment that is used on more familiar spiral bevel gears and hypoids. You can also use the same testers, quenching presses and other auxiliary Gleason equipment you're using now. Grinders are available for applications requiring precision finish.

High-ratio hypoids can be produced by the Gleason Works for ratios of 1:10 or 1:40 or even higher. They are finding a growing number of applications in such diverse fields as farm machinery, instrumentation and office equipment.

You can get more information about Gleason high-ratio hypoid gears by writing for free literature. Submit your prints for recommendations.

GLEASON WORKS

1000 UNIVERSITY AVE., ROCHESTER 3, N.Y.

CIRCLE 89 ON READER SERVICE CARD

*Trademark of Metals & Controls Inc.

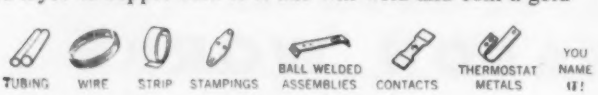
. . . we'll put them together for you

When you are choosing materials for new designs, or when conducting value analysis on existing products, don't compromise on the qualities the parts must have. If you are now using single metals or alloys, chances are you're compromising.

For example, if you need thermal and electrical conductivity, and springiness, no one metal can give you the optimum in all three requirements.

That's where MULtiLAYER clad metals fit into the picture. We will give you a spring steel base material with a layer of copper clad to it and will weld and coin a gold contact ball onto the blade for electrical conductivity. Besides giving you more beneficial engineering properties, MULtiLAYER will probably save you money because you will need less precious metal.

MULtiLAYER, with its hundreds of possible combinations, gives you another modern material. Take advantage of it. WRITE for our general catalog, GP-1B, which describes this material in more detail and illustrates many thought-provoking applications.



METALS & CONTROLS INC.
1007 FOREST STREET • ATTLEBORO, MASS.
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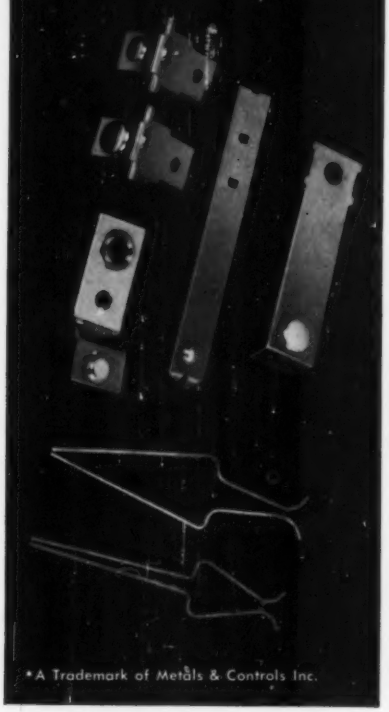
MULtiLAYER*

Welded Assemblies Eliminate RIVETS & BUTTONS



*A Trademark of Metals & Controls Inc.

Take a strip of spring steel, clad an overlay of copper to it, weld and coin a precious metal ball at the exact contact point. The result . . . a MULtiLAYER relay part with operating qualities impossible to obtain through the use of any single alloy or plated material. When blanked and cut off, this part gives you maximum reliability, peak performance without compromise, occupies a minimum of space and costs a fraction of parts made by conventional methods. Especially when produced in quantity by our time-proven direct cladding methods, four-slide presses and custom designed welding equipment.

Similar parts from wire, inlay and overlay strip, and other MULtiLAYER clad metals produce the same benefits. Our field engineers in your territory will help you apply this modern design material to your products. Write, call, or wire Marketing Manager, Precision Electrical Parts Dept.

METALS & CONTROLS INC.
1007 Forest St., Attleboro, Mass.
A corporate division of
TEXAS INSTRUMENTS INCORPORATED

available with 0.250-in. bore; other has 17 ft-lb torque capacity and is available in bore sizes of 0.375 and 0.500 in. Designed for continuous over-running speeds up to 3450 rpm on one model and 2400 rpm on other. Gears, sprockets, pulleys and similar devices for connecting clutches to driven equipment can be mounted on clutch OD. **Formsprag Co, 23601 Hoover Rd, Warren, Mich.**

Circle 316 on Reader Service Card

Torque collar . . .

combines threaded mounting flange and independent-acting, spring-locking shaft collar into a one-piece unit. Locking action, achieved without a threaded fastener, compares to a shrink fit. Transmits torque or thrust loads without keys, keyways, setscrews or shaft shoulders to pulleys, sprockets, gears, cams, etc. Available in sizes from ½- to 2-in. bores. **Kolock Products Co, PO Box 200, Lutherville, Md.**

Circle 317 on Reader Service Card

Predetermining counters . . .

available in 1-, 2-, 3- or 4-digit models, operate from any external circuit or from plug-in photoelectric or magnetic-impulse amplifiers and pickups, linear footage measurement wheels and others. Output control relay has heavy-duty contacts that handle stop-motion, cut-off actuation, cyclic operation, etc of all types of production machinery. Max counting rate is 3000 per min. Automatic reset and restart occurs within 0.005 sec. **Standard Instrument Corp, 657 Broadway, New York 12.**

Circle 318 on Reader Service Card

Thermocouple material . . .

is ceramic-insulated, metal-sheathed and spectrochemically clean product that is its own insulator and conduit. Made for ordinary electrical leads with single or multiple conductors and can be coiled or bent on a radius as small as own diameter. Said to be suitable for use in corrosive media and gases and to provide max pro-

continued on page 92

VERS-O-LINE
bearings by Hartford

PRE-VALUE ANALYZED
for your product

Hartford's Vers-O-Line is constantly expanding to meet the demand of value analysts for one economical unit to replace several more costly integral parts. Instead of specifying more costly precision bearings explore the possibilities of Vers-O-Line. Hartford engineers can help your design engineers by recommending or adapting a bearing from a wide variety available in stock or can imagineer a new design to meet your product specification that can be produced to effect substantial savings.

Hartford's Vers-O-Line bearings include:

RADIAL . . . H-Series
RADIAL . . . Conrad Loaded
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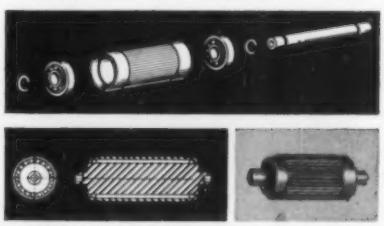
THRUST
VERSA-TWIN . . . Twin Row

BEFORE—Six separate parts, expensive bearings and costly to assemble.



AFTER—One complete economical assembly, reduced parts, maximum stability.

Write for comprehensive technical literature containing case history applications and helpful bearing ideas.

Specify Hartford PRECISION BALLS • BEARINGS

HARTFORD STEEL BALL COMPANY
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Small Size and Long Life Make G-E Glow Lamps Ideal as Indicators

There are over 60 General Electric glow lamps made especially for use as indicators in appliances, business machines, military equipment—wherever indicating devices are needed. They're small, rugged, usually low-cost, operate on standard AC voltage at low wattage and give off very little heat. All of which makes them ideal for use as indicators. Here are details on a few of them:

NE-2H lasts 25,000 hours on standard AC voltage,* only ¾ inch long, operates on just ⅛ watt, is a high brightness lamp and costs much less than a dime including an attached resistor (5 different resistors are available).

NE-2J another high brightness lamp with a 25,000 hour life* on standard AC voltage, operates on ⅛ watt, is less than one inch long, has a single contact midget flange base and will fit most standard indicator fixtures. This lamp is not available with attached resistor.

NE-45 has a 7,500 hour average useful life on standard AC voltage; operates on ¼ watt, is 1 17/32 inches long, has 30K resistor built into screw base and big electrode that presents a large glowing area when lit.

**With a 30K resistor.*

For detailed information on the 18 most popular General Electric glow lamps, write for bulletin #3-0193. General Electric Co., Miniature Lamp Dept. M-134, Nela Park, Cleveland 12, Ohio.

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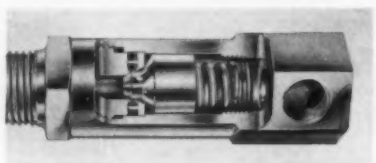
tection in high-pressure, severe vibration and extreme temperature conditions. Single-pass swaging process densely packs material's insulation without stretching, flattening or distorting the wire. Can be supplied as part of a thermocouple assembly with appropriate hot junction, mounting, bushing, connection head and other components. Available also by the ft, in standard lengths of 25 to 37 ft random, as well as continuous lengths up to 100 ft and over by special order. **Temptron Inc, 7030 Darby Ave, Reseda, Calif.**

Circle 319 on Reader Service Card

Slide switches . . .

for motors, tools and appliances, are rated 6 amp at 125 v ac and 1 amp at 125 v dc. Available in SP and DP, each with 1, 2 and 3T circuits. Over-all height from terminal tip to trigger top is 1 in. and from mounting surface to terminal tip, 0.676 in. Width is 0.573 in. max and over-all length of 1 and 2T units is 1.406 in. Length of triple-throw switch is 1.660 in. Prices are said to be from 35 to 75% less than comparable units. **Continental-Wirt Electronics Corp, Dept E-1, 26 W Queen Lane, Philadelphia 44.**

Circle 320 on Reader Service Card



Relief valves . . .

available in three models, are rated at 10 gpm and cover range from 50 to 2000 psi. Incorporate flexible seal seats for leak-tight sealing and adjustment locks, allowing constant pressure settings. Made of steel, equipped with Teflon seals, they are stocked in 10 connection combinations of ¼-, ⅜- and ½-in. dryseal pipe. **Kepner Products Co, 7341 W 59th St, Summit, Ill.**

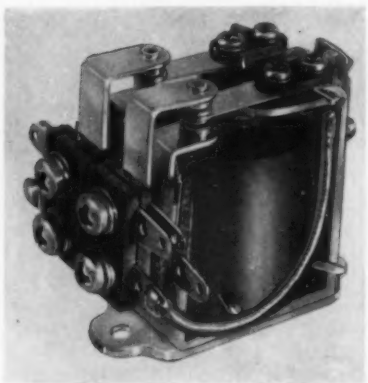
Circle 321 on Reader Service Card

Top entry ball valves . . .

are one-piece units made of cadmium-plated carbon steel or stainless steel bar stock that are said to provide fuller flow than other ball valves for same pipe sizes. Enlarged flow passage reportedly has an orifice area 17% larger than other 1-in. valves; 35% larger than other ¾-in. models; and up to 40% more than other ⅜- and ½-in. units. Max pressure-temp ratings are 150 psi at 365 F for steam lines and 1000 psi for water, oil, liquid,

chemical and gas-handling applications. Heart of design is a hard chrome-plated bronze or stainless steel ball, resting between seals of Buna N or Teflon. Flow passage is precision-drilled through ball in diameters of 0.500 in. or ⅜- and ½-in. sizes; 0.625 in. on ¾-in. size; and 0.824 in. on 1-in. models. Shaft extending from ball through top cover permits rotation of ball over a 90° arc by turning a top-mounted handle. Strong, 508 Sandusky St, Conneaut, Ohio.

Circle 322 on Reader Service Card



Dc relay . . .
is available in SPDT contact arrangement for 100 milliw operating power and SPDT contact arrangement for 200 milliw power. Adjustments enable sensitivities as low as 15 milliw for SPDT unit and 70 milliw for DPDT unit. Standard coil resistances are 2500, 5000 and 10,000 ohm. Contacts are rated 5 amp resistive at 115 v ac or 26.5 v dc. Material is ⅛-in.-dia fine silver. Temp range is —49 to 185 F; dimensions, 2 x 2⅛ x 1¾ in. Priced at approx $3, with delivery from stock on standards; 4 to 6 wk on special orders. Elgin Advance Relays, Electronics Div, Elgin National Watch Co, 2435 N Naomi St, Burbank, Calif.

Circle 323 on Reader Service Card

Linear motion potentiometers
include short travel and hi-temp, long travel units. Former is sensitive to movement as small as 0.00006 in. and can be used to sense small deflections and bending movements of structures, position of miniature valves or linkages and similar applications. Spring-loaded shaft drives a flexure-supported wiper assembly that multiplies input motion for fine resolution without introducing friction or backlash errors. Range is from 0.015 to 0.070 in. total travel; resistance, 500 to 5000 ohm, ±5%; power rating, 0.1 w continuous at 400 F; size, ⅜ in. dia x 1½ in.; and weight, 1.3 oz. Other instrument was designed to meet need for long travel unit that would operate at 500 F

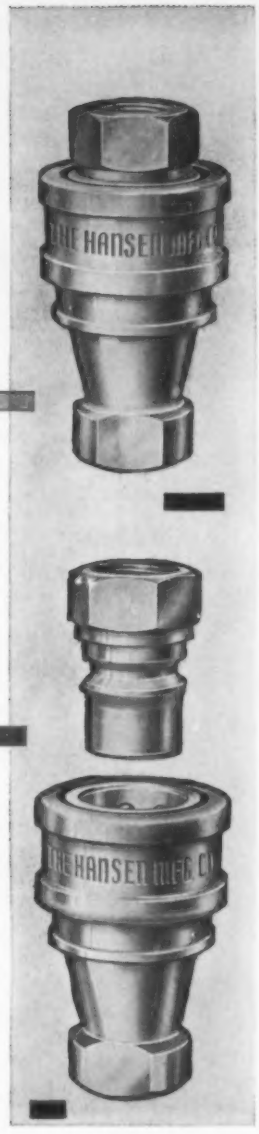
continued on page 94

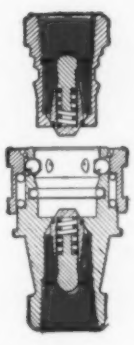
HANSEN

TWO-WAY SHUT-OFF COUPLINGS

QUICK CONNECTION OR DISCONNECTION OF FLUID LINE CIRCUITS WITH INSTANT AUTOMATIC FLOW OR SHUT-OFF

Instantly shuts off both sides of circuit...prevents loss of liquid, gas or pressure





When Coupling is disconnected, identical valves in both the Socket and Plug provide instant shut-off of gas or liquid. To eliminate leakage or spillage during disconnection, the Coupling is so designed that shut-off takes place *before* the Plug separates from the Socket—and *before* the seal of the Socket itself, provided by the Socket "O" Ring, is broken.

In reverse, when Coupling is connected, the "O" Ring in the Socket completely seals Coupling *before* valves release flow of fluid from both sides of circuit—thus eliminaitng possibility of spurt of gas or liquid during instant of connection.

Available in brass or steel with female pipe thread connections from ⅛" to 1½" inclusive—also up to 1" in stainless steel.

Quick-Connective Fluid Line Couplings for

COMPRESSED AIR • HYDRAULIC FLUIDS
WATER • VACUUM • STEAM • GASOLINE
ACETYLENE • REFRIGERANTS • OXYGEN
OIL • GREASE • COOLANTS • LP-GAS

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Here is an always ready reference when you want information on couplings in a hurry. Lists complete range of sizes and types of Hansen One-Way Shut-Off, Two-Way Shut-Off, and Straight-Through Couplings.

Representatives in Principal Cities... see Yellow Pages

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NEW...

BLH-BUILT STRAIN INSTRUMENTS ARE EASIER TO READ, SIMPLER TO OPERATE

BLH announces new instrumentation policy. New instruments marketed by the world leader in strain and force measurement will now be designed and built entirely by instrument specialists in the modern BLH facility in Waltham, Mass. This policy will provide improved instruments with single-source responsibility and more favorable pricing.

Digital strain indicator sets a new standard for ease of operation and readout. It features digital readout to eliminate interpolation from dials and meters, wider gage factor (1.50–4.50) and gage resistance range (60–2000 ohms), battery or ac operation, and accuracy within 0.1% of reading or 5 microinches/inch. This portable unit is transistorized, weighs only 18 lb., has a durable Formica case, and is low in cost.

Switching and balancing unit, for use with any BLH strain indicator, permits readings to be taken on each of a group of gages. Speeds up test work where time is an important factor because of ambient temperature variations, creep, inherent characteristics of the test material, or limited availability of test facilities. Units can be stacked to handle gages or gage configurations in multiples of 10. Simplified gage connection board. Special friction drive zero adjustments require no locking.

Improved repeatability—better than 1 microinch/inch for a half-million channel selector switch rotations. Long-life Formica case.

Local availability through BLH sales engineering representatives in the U.S. and Canada. See the one nearest you or write direct for data sheets.

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Electronics & Instrumentation Division
Waltham 54, Mass.

FIRST in force measurement

SR-4® Strain Gages • Transducers • Temperature Sensors • Systems

and give accurate high level potentiometer output. All exposed areas of the instrument are stainless steel, while potentiometer element itself is precision wound with platinum alloy wire. Specifications include: range of 0-9 in.; linearity, ±0.25%; resistance, 5000 ohm ±5%; resolution, 0.045%; power rating, 0.1 w at 500 F; size, 1.4 in. dia x 12 in.; and weight, 2.5 lb. Bourns Inc, 6135 Magnolia Ave, Riverside, Calif.

Circle 324 on Reader Service Card

Servo mounting clamps . . .

in two sizes, each anodized in a different color, can be used on total of six different housing sizes. One clamp style is for component sizes 8, 10, 11 (commercial) and 11 (military); other clamp style is for component sizes 15 and 18. Each piece is machined from solid aluminium stock to provide greater strength under shock and vibration than conventional powdered metal and stamped construction. From stock at 19¢ each in quantities of 100; 15¢ each, quantities of 500; and 10¢ each, quantities of 1000. Theta Instrument Corp, 520 Victor St, Saddle Brook, NJ.

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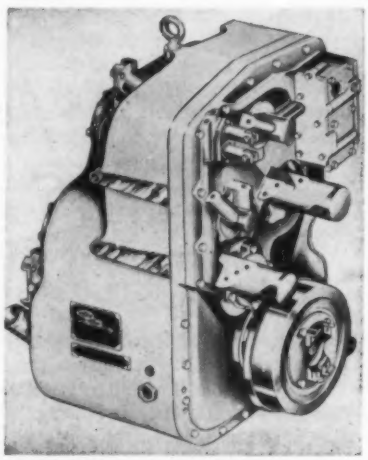


Power-shift transmission . . .

is 4-speed forward, 4-speed reverse box with full power shifting in all speeds. Designed for engines developing from 75 net hp (1800 rpm) to 108 net hp (3000 rpm) and includes two models with overall ratio coverage of 6.91:1. One model has ratios of 4.89, 3.19, 1.08 and 0.705; others model's ratios are 5.98, 3.92, 1.32 and 0.866. Has simple countershaft arrangement, in which multiple-disk, oil-actuated clutches energize constant-mesh spur gear trains. Speed changes are ef-

fected by duplex clutches that function as range clutches, while two large individual clutches handle direction-changing job. These oil-cooled clutches act as energizing clutches for all engagements. Normally furnished with single-stage torque converter as package unit. **Transmission Application Engineering Dept, Twin Disc Clutch Co, Racine, Wis.**

Circle 326 on Reader Service Card

Universal motor . . .

2¼ in. dia, has nominal rating of up to 1/70 hp at 10,000 rpm. Stack length can be varied from 3¼ to 4 in. long, depending upon required output torque. Delivers 10-in.-oz output torque at 10,000 rpm with a current of 1.3 amp at 115-v ac, 60-cps power. Field and armature windings can be varied to provide different speed-torque characteristics. Weighs 24 oz. **Globe Industries Inc, 1784 Stanley Ave, Dayton 4, Ohio.**

Circle 327 on Reader Service Card

Nail clips for breadboard . . .

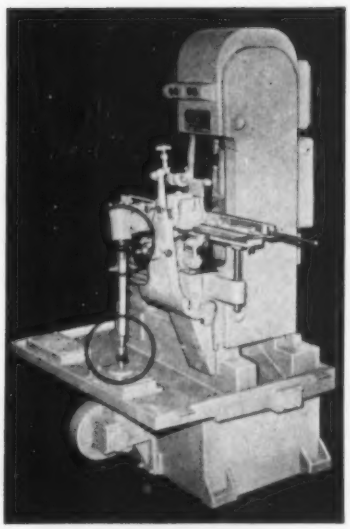
layouts, also hold wire ends in place on harness boards, demonstration boards and experimental hookups built on plywood boards and similar materials. Mount on boards with hammer and simple driving tool, requiring no prior drilling or counterboring. Made of stainless steel and nylon, they hold up to four or more wires each. T-shape provides pressure ledge for easy finger-tip operation, and thin, flat design is said to eliminate damage to boards when engineering changes are made. Connectors clamp wires in vise-like grip and reportedly won't cut, nick or kink wire ends. Priced at $.27 each in quantities of 1-49; $.24 each in 50-99 lots; $.22 each in 100-249 lots; $.16 each in 250-1999 lots; $.14 each for 2000-4999 units; and $.12 each for 5000 and more units. Delivery within 5 days on small orders; 2 to 6 wk on large orders. **E-Z Hook Test Products, 1536 Woodburn Ave, Covington, Ky.**

Circle 328 on Reader Service Card

FROM FIXED DRIVE TO ADJUSTABLE CENTERLESS FEED

APEX UNIVERSAL JOINTS

The rate of feed on Production Machine Company's finishing and polishing machines is readily adjusted by tilting the centerless feed housing. Two Apex universal joints—one connected to a fixed motor shaft, a second connected to the adjustable feed unit—provide quiet, efficient operation at any adjustment angle.



And because finishing and polishing metal, fibre, plastic, rubber and wood create an abrasive atmosphere of tiny particles, these are Apex *covered* universal joints . . . all abrasive particles are sealed OUT, clean, sustained lubrication is sealed IN.

Apex covered universal joints operate in fluids, gases, corrosive or abrasive atmospheres, and in extremes of temperatures. Apex universal joints, covered or uncovered, ¼" to 4" diameter stock sizes, full range of hub types.

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SEE OUR CATALOG IN SWEET'S

or write, on your company letterhead please, for Catalog 28 and Data Sheet. For special applications, send sketch or print for prompt recommendations and quotation.

THE APEX MACHINE & TOOL CO.
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Phantom view of Apex universal joint with lubricant-retaining cover, an exclusive Apex development. Apex covered joints operate efficiently in wet, dry, corrosive or abrasive atmospheres and at extremes of temperatures.

TO BOND SANDWICH CORE USE METLBOND 406

today's most advanced metal-fastening adhesive system

METLBOND 406 is a large-area, one-component, low-pressure, dry, epoxy-based adhesive system. METLBOND 406 will bond similar or dissimilar metals faster, cheaper, better. No core or skin primer is required.

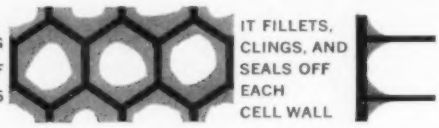
METLBOND 406 IS EASY TO USE. It can be cut, placed in position, and cured with low pressure, at moderate temperatures. Since it is a non-supported system, there is no fabric carrier. Therefore, during cure, it flows... goes where you want it! For most structural metal-joining operations, use METLBOND 406—the "educated" adhesive. It can measurably cut your fabrication costs.

IMPORTANT CHARACTERISTICS OF METLBOND 406

Effective operating temp. range	—430F to +200F
Room temp. shear strength	5500 psi
Room temp. peel strength (in.-lbs. per 3-in. width)	125

A dual-purpose adhesive system which can be used to bond metal-to-metal, or core-to-skin with equal effectiveness.

FILLETING ACTION OF METLBOND 406



IT FILLETS, CLINGS, AND SEALS OFF EACH CELL WALL

Please write for descriptive product data.

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DIVISION NARMCO INDUSTRIES, INC.
SUBSIDIARY OF **TELECOMPUTING CORPORATION**
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NARMCO – for high-performance materials. Formulators of: Structural and Industrial Adhesives · Reinforced Plastic Laminating Materials · Ablative and Molding Compounds · Insulating Compounds.

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PRIOR CONVENTIONAL AXLES

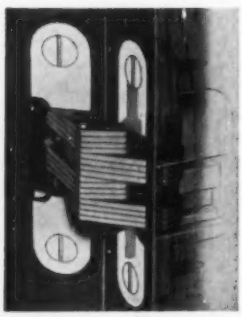
Available in all standard sizes up to 2" and in custom sizes on special order. Singles and tandems, straight and drop axles. Complete running gear assemblies. Let us help you solve your running gear design problems. For further information, write

PRIOR PRODUCTS, INC. P. O. BOX 7008 · DALLAS, TEXAS

NEW INVISIBLE HINGES

General Purpose Hinge

Creates Flush Surfaces



These hinges are completely hidden from view when door, lid or hood is closed. Makes possible flush, absolutely smooth surfaces that greatly enhance appearance and safety. Tapered body sections are precision castings of a special zinc base alloy having a tensile strength of 47,000 pounds per square inch. Operates in a 180 degree arc which permits full opening. Laminated link construction reduces friction and permits hinges to operate freely and smoothly. Hinges are reversible and may be used right or left hand. Available for wood or metal application in a wide variety of sizes. For complete details, prices and free illustrated catalog, write today to

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P. O. Box 38, Harper Station, Detroit 13, Mich.

CIRCLE 96 ON READER SERVICE CARD

CIRCLE 206 ON READER SERVICE CARD

DESIGN LITERATURE

The Language of Science

William Gilman. Harcourt, Brace & World Inc. 750 Third Ave, NY 17, 5½ x 8, 248 pp, $4.95.

"And God said: Let there be light, and there was light."

That first scientific report comes to us through the mists of centuries, yet is still clear and unambiguous. What if our religious writings, however, had resembled much of today's language of science? Suppose, instead of the simple statement quoted above, we had been straddled with:

> In response to a verbal stimulus for luminosity, initiated by the Master Control, a complete spectrum of visible radiation occurred.

It is, of course, quite possible that one result of such language would be to convert many of today's scientific agnostics. But this very fact reveals a basic fault—there is today too much worshipping at the feet of the false gods Mumbo-Jumbo, Gobbledygook and Jargon.

If a scientific or other technical report sounds "scientific" its status often approaches that of a sacred cow; to challenge it is almost heresy.

That is one fault of the "bad language of science." It is often deliberate; done by those whose high-flown writings must cloak philosophical trivialities, insignificant test-results or paltry modifications of advertised products. But in *The Language of Science; A Guide to Effective Writing*, William Gilman has produced a book for all of us who, for one reason or another, have to report engineering and scientific findings honestly, and write to be clearly understood by the intended reader—for there lies the far worse fault in today's science writing, a failure to communicate clearly. There is an ever-growing danger that instead of giving us a map to the stars, the science writings of today will be nothing more than a scrabble of unrelated place-names in an atlas-maker's box of index cards.

The ability to write "correct English" is the least of the problems. This must, of course, be acquired first. But rules of grammar are rather like the touch lines of a football field—they mark the boundaries of play. If a ball goes outside them, every player knows what he is doing and why.

Therefore Gilman devotes one entire chapter to "Hyphen Horrors." His reason: "If hyphens can be tamed by common sense, without getting lost in a labyrinth of grammar, so can other troubles with writing."

Other entire chapters are given to new words, the answers to jargon, simple words that are deceptive, words that say it best, fast-moving sentences, an equation for clarity, a good "lead" that starts you off with flying colors, assembling your thoughts and findings, looking over your complete work for such things as "two-faced" words ("this gear is *flexible*"—you really mean *versatile*), style, and other subjects. For there are many quicksands in science writing, waiting to trap even the best of writers unless they are continuously alert.

Gilman's guide is delightful to read; his whimsical humor is ever ready to give us a lift. But this guide to new frontiers of efficient communication is also thorough. And it cautions against taking advice to "write just as you talk" as a simple cure-all for bad writing. As Gilman points out, craftsmanship is needed to make the complex seem simple.

The New York *Times*, *Scientific American*, *The New Yorker*, and other media are recipients of a fair share of brickbats and bouquets. The fact that "Bill" Gilman happens to be copy editor for PRODUCT ENGINEERING accounts, for the goodly number of examples he gives of both good and bad engineering writing. He has written an excellent book that takes the mystery out of scientific and technical communication. DCG

Sheetmetal Drafting

MELVIN L BETTERLEY, prof of engineering drawing, State U of Iowa. McGraw-Hill Book Co, 330 West 42nd St, New York 36. 7 x 10, 314 pp. $4.50.

This book covers all phases of drawing: techniques, projection principles, and descriptive geometry, integrated and applied whenever possible to situations in the sheet metal field. It concentrates on basic principles that can be applied to numerous situations. The logic behind various procedures

continued on page 99

High-torque, fast-reversing Barber-Colman a-c motors

(with or without gearheads)

Ideal for low-cost servo systems utilizing either transistor or vacuum-tube control, these compact, powerful shaded-pole motors are adaptable to a variety of electronic control circuits. In many systems they satisfactorily replace motors costing twice as much. Adaptable to split-phase capacitor operation . . . available with open or enclosed gear reductions . . . 2-phase or electronic control windings. Ratings are from .00015 to .04 hp. Fast-reversing low-inertia rotors . . . high starting torque . . . electrodynamic braking . . . quality guaranteed!

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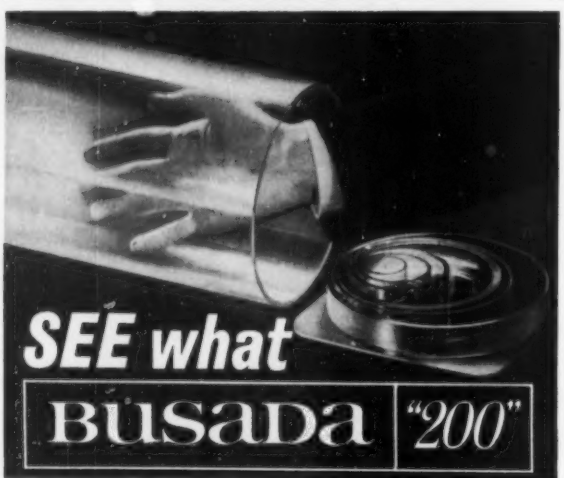

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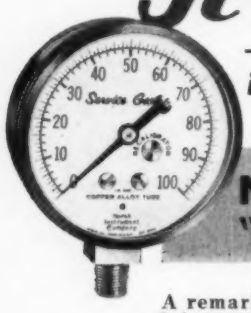

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is discussed, rather than step-by-step directions on how to solve simple problems.

Other Books of Interest

Research on High-temperature Ferroelectric Storage Media

PB 161805, Charles F Pulvari. Office of Technical Services, US Dept of Commerce, Washington 25, DC. 8½ x 11, 115 pp. $2.75.

Experimental Investigation of Effects of Random Loading on the Fatigue Life of Notched Cantilever-beam Specimens of SAE 4130 Normalized Steel

NASA TN D-663. Robert W Fralich. Office of Technical Services, US Dept of Commerce, Washington 25, DC. 8 x 10¼, 19 pp. 50¢.

Weight-strength Analysis of Aircraft Structures

F R Shanley. Dover Publications Inc, 180 Varick St, NY 14. 5¼ x 8, 404 pp. $2.45.

Paperback edition of book originally published in 1952, has new preface, biliographies and other new material.

ABSTRACTS FROM THE LITERATURE

Fabricating Clad Steels

Clad steels are now finding wide application in many industries; this article describes the production and special properties of four main types—Monel, nickel, ferritic and austenitic stainless steels.

"Fabrication of Clad Steels," by S. Rowden, Ashmore, Benson, Pease & Co Ltd, Engineering Materials and Design, June 1960. Heywood & Co Ltd, Drury House, Russell St., London WC 2, England.

Acceleration Switching Valve

Contains some practical considerations based on real experience with the electrohydraulic switching valve, plus sufficient theoretical exposition to give a good fundamental understanding of its behavior.

"The Acceleration Switching Valve Still Has Advantages," by Morton E. Moore, Autonetics Div, North American Aviation Inc, Control Engineering, June 1960, 330 W 42nd St, NY 36.

Testing Small Tubing

This article compares eight nondestructive testing methods—visual, boroscopic, eddy current, dye penetrant, magnetic particle, ultrasonic, radiographic, and hydrostatic—which can be employed to locate defects in tubing nondestructively. Though eddy-

continued on page 101

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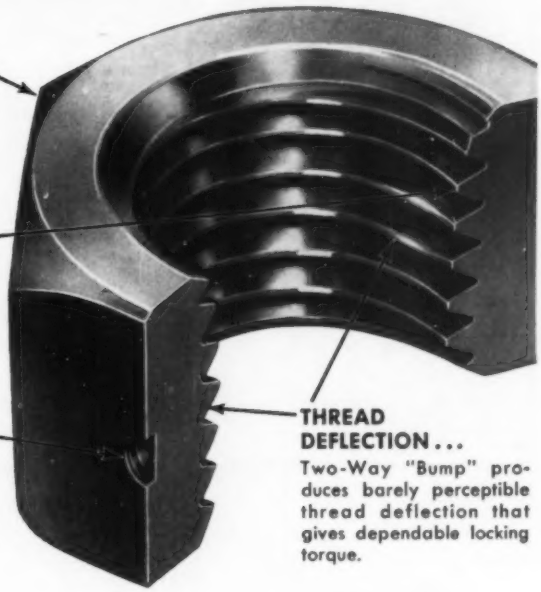

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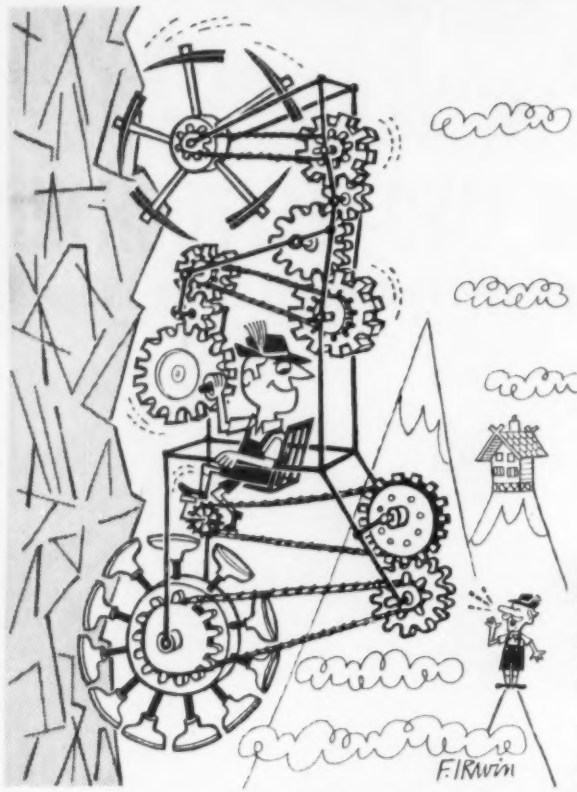

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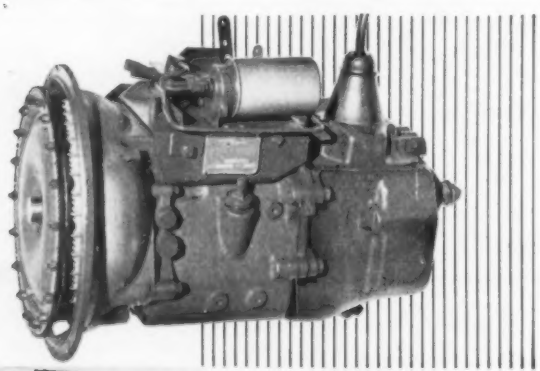

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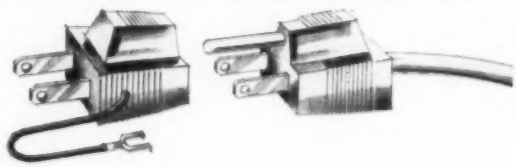

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current testing is considered to be the most versatile method in present use, no one test can give a complete answer by itself.

"Nondestructive Testing of Small Tubing," by J. R. Grievor, and A. M. Bounds, Metallurgical Dept, Superior Tube Co., Norristown, Pa., Metal Progress, Dec 1960, American Society For Metals, Metals Park, Novelty, Ohio.

Flexible Polyether Urethane Foams

This article describes a process for molding thin sections of one-shot polyether foams in thin gage metal molds. A unique feature of the process is a high-output source of radiant heat.

"Molding Flexible Polyether Urethane Foams," by P. G. Gemeinhardt, J. F. Szabot, A. S. Morecroft & J. H. Saunders, Mobay Chemical Company, SPE Journal, Oct 1960, Society of Plastics Engineers, 65 Prospect St, Stamford, Conn.

Liquid Level in Tanks

There are many ways to measure liquid level. There are systems using electrodes, pressure gages, differential type meter bodies, floats, strain gages, or radiation sources. In some installations, these systems merely indicate the contests of storage tanks, in others, they control the level of capacity or surge tanks to keep process flows steady, or regulate the quantity of material supplied to vessels in which there are chemical reactions or physical blending. The article explains systems: Static pressure method, pres-

continued on page 103

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"What's the Level in the Tank?", Instrumentation, Vol. 13, No. 3, 1960, Wayne & Windrim Ave, Philadelphia 44.

CATALOGS AND BULLETINS

To obtain copies of literature described below, circle corresponding number on postcard inside back cover. For those catalogs and bulletins available only when requested on company letterhead, see page 106.

ROTARY PUMPS—Catalog 3600, 16 pp. Describes, illustrates and supplies performance tables and dimension drawings of components and pumps in a general purpose, low rpm line. Examples are shown of bedplate-mounted, gasoline engine and electric motor-driven units. Roper Hydraulics Inc, Commerce, Ga.

Circle 350 on Reader Service Card

POLYPROPYLENE—Bulletin 9, 7 pp. Traces properties and characteristics of the material and carries tables covering (1) its resistance to chemicals; (2) typical physical properties of the plastic in injection molding; and (3) suggested formulas for various processing methods. Eastman Chemical Products Inc, Sub of Eastman Kodak Co, Kingsport, Tenn.

Circle 351 on Reader Service Card

WIRE-WOUND RESISTORS—Catalog, 20 pp. Contains specifications, dimensions, performance curves, and photographs of miniature, subminiature, axial lead, lug, printed circuit, high frequency, card-type, ceramic and hermetically sealed types, as well as complex resistor networks. Also includes discussion of high reliability resistor program and cross reference chart with Mil Specs. Daven Co, Livingston, NJ.

Circle 352 on Reader Service Card

COPPER-CLAD LAMINATES – Brochure B8215, 8 pp. Compares physical and electrical properties of seven grades or types of copper clad laminates for printed circuits. Recommended applications are included for each laminate. Westinghouse Electric Corp, Micarta Div, Hampton, SC.

Circle 353 on Reader Service Card

CAST IRONS—Folder, 6 pp. Properties and specifications of approx 40 irons and alloys are tabulated, while heat treat service is discussed. Hamilton Foundry Inc, 1551 Lincoln Ave, Hamilton, Ohio.

Circle 354 on Reader Service Card

SOLENOID VALVES—Manual 108, 16 pp. Covers solenoid valve selection for corrosive applications and includes a discussion of valve construction; list of over 500 corrosive chemicals commonly used in industry; valve selection charts; diagrams showing normally closed and normally open configurations; a flow-vs-pressure drop chart; and general data required to select proper solenoid valve for a specific application. Valcor Engineering Corp, 365 Carnegie Ave, Kenilworth, NJ.

Circle 355 on Reader Service Card

FLEXIBLE METAL HOSE—Catalog 600, 32 pp. Covers advantages of corrugated and interlocked hose; principle classes of motion; proper installation and use; correction factors, temp limits, etc. Details how to determine correct hose length and describes standard assemplies—giving their construction, materials used, fittings, features, applications and common media for each. Atlantic Metal Hose Co, 308 Dyckman St, New York 34.

Circle 356 on Reader Service Card

DYNEL OVERLAYS—Booklet T-2045, 8 pp. Outlines uses of protective overlay fabrics of Dynel modacrylic fiber to overcome problems of wear, weathering and chemical attack on glass-reinforced plastic laminates. Details Dynel's specific resistant properties. Textile Fibers Dept, Union Carbide Chemicals Co, 270 Park Ave, New York 17.

Circle 357 on Reader Service Card

DIAPHRAGM-OPERATED VALVE – Bulletin, 2 pp. Covers specifications, construction materials, dimensions and operational data on the snap-acting, 3-way unit. Outline drawings are included. G W Dahl Co Inc, 86 Tupelo St, Bistol, RI.

Circle 358 on Reader Service Card

PLASTIC TUBING – Catalog, 12 pp. Offers data on sizes, max working pressures, chemical resistances and prices. Cobon Plastics Corp, 44 Lafayette St, Newark 2, NJ.

Circle 359 on Reader Service Card

RESEARCH AND CONTROL INSTRUMENTS—Catalog 1961-62, 224 pp. Carries specification and performance data on thermistor-based instrumentation; environmental testing equipment; chemically-resistant liquid transfer and metering pumps; temperature control and heat treating equipment; and new developments in chromatography. Cole-Parmer Instrument & Equipment Co, 7330 N Clark St, Chicago 26.

Circle 360 on Reader Service Card

LOCK WASHERS—Booklet AS-105, 12 pp. Discusses and illustrates proper lock washer for general use; for spanning oversize holes; for heavy nuts and bolts; for flat or oval head screws; for grommet retainer use; for extreme fastening stresses and for special problems. Table summarizes

continued on page 105

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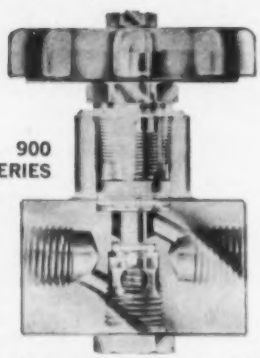

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reasons for using specific types to solve various application problems. Shakeproof Div, Illinois Tool Works, St Charles Rd, Elgin, Ill.

Circle 361 on Reader Service Card

MACHINING LAMINATED PLASTICS Brochure 3100, 8 pp. Contains 11 illustrated design hints for laminates and covers techniques for machining with recommended tools to be used, speeds, feeds, cooling and lubrication. Synthane Corp, Oaks, Penna.

Circle 362 on Reader Service Card

DECIMAL EQUIVALENTS FOR WIRE GAGES—Card stock chart, 11 x 14 in. Converts Birmingham wire gages (36 to 1) and fractions (1/64 to 1 in.) to decimals. Ohio Seamless Tube, Div of Copperweld Steel Co, Shelby, Ohio.

Circle 363 on Reader Service Card

ELECTRONIC SPEED & LOAD SENSING GOVERNOR—Bulletin GEA-7231, 2 pp. Describes operation and tabulates performance characteristics. Includes block diagram of system and actual speed trace demonstrating unit's performance under application and removal of full load. General Electric Co, Schenectady 5, NY.

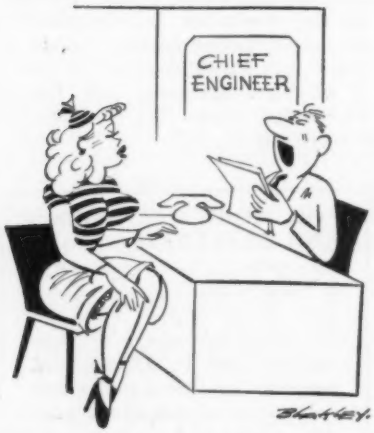
Circle 364 on Reader Service Card

POST-TYPE BRAKES—Bulletin, 2 pp. Supplies available sizes, design features, drum and shoe dimensions and capacities of heavy-duty units. Hart Reduction Pulley Co, 1116 Adams St, Waukesha, Wis.

Circle 365 on Reader Service Card

BIDIRECTIONAL COUNTERS—Bulletin, 2 pp. Contains specifications, performance characteristics and dimension drawings showing panel mountings and receptacle connections. Counters covered are

continued on page 106



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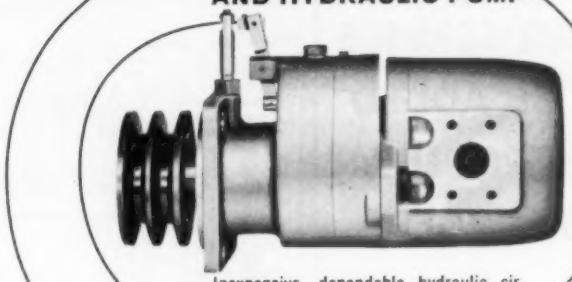

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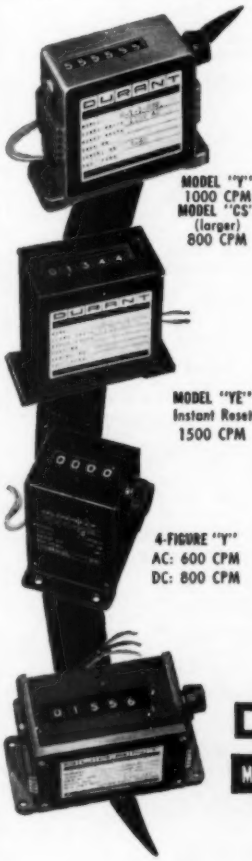

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INDEX TO ADVERTISERS

This index is published as a convenience to the readers. Every care is taken to make it accurate but PRODUCT ENGINEERING assumes no responsibilities for errors or omissions

Aeroquip Corp. 85
Alemite Div., Stewart-Warner Corp... 45
American Cast Iron Pipe Co..... 5
American Chain & Cable Co., Inc., Automotive & Aircraft Div..... 56
Apex Machine & Tool Co..... 95
Armstrong Cork Co..... 2
Arwood Corp. 30

Baldwin-Lima-Hamilton Corp., Electronics & Instrumentation Div. 94
Barber-Colman Co. 97
Bellows-Valvair Div., International Basic Economy Corp..... 41
Berry Hydraulics Div., Oliver Tyrone Corp..... 107
Boston Gear Works..... 49
Bower Roller Bearing Div., Federal-Mogul-Bower Bearings, Inc..... 38
Busada Mfg. Corp..... 98

Chemical Products Corp..... 28
Chicago Molded Products Corp., Custom Molding Div..... 44
Chiksan Co., Subs. of Food Machinery & Chemical Corp..... 13
Circle Seal Products Co., Inc..... 104
Cone-Drive Gears Div., Michigan Tool Co. 80
Cutler-Hammer, Inc. 98

du Pont de Nemours & Co., (Inc.), E. I., Film Dept..... 10
Durant Mfg. Co..... 107
Dynamic Gear Co., Inc..... 100

Emerson Electric of St. Louis..4th Cover

Fairfield Mfg. Co., Inc..... 83
Fenwal, Inc. 50
Funk Mfg. Co..... 100

Gardner-Denver Co. 88
General Controls Co. 105
General Electric Co., Miniature Lamp Dept..... 92
General Electric Co., Silicone Products Dept..... 42
Gleason Works 89
Globe Industries, Inc..... 36

Handy & Harman..... 26
Hansen Mfg. Co..... 93
Hartford Steel Ball Co..... 91
Heim Co. 52

Johns-Manville Corp. 78

Kaupp & Sons, C. B..... 32

Lamina Dies & Tools, Inc..... 37
Lincoln Engineering Co..... 11

McLouth Steel Corp..... 51
MB Electronics Div., Textron Electronics, Inc..... 33
MacLean-Fogg Lock Nut Co..... 99
Malleable Castings Council.....34-35
Marsh Instrument Co., Div. of Colorado Oil & Gas Corp..... 98
Masland Duraleather Co., The..... 53
Michigan Tool Co., Cone-Drive Gears Div..... 80
Miller Electric Co..... 100
Mt. Vernon Die Casting Corp..... 48
Mueller Brass Co.....86-87

Narmco Materials Div., Subs., Telecomputing Corp. 96
National Seal Div., Federal-Mogul-Bower Bearings, Inc. .....3rd Cover
Nicholson & Co., W. H..... 101
Nordson Corp. 86

Ohio Precision Castings, Inc..... 105

Palnut Co., Div., United-Carr Fastener Corp. 29
Prior Products, Inc..... 96
Protective Closures Co., Inc., Caplugs Div. 43

Republic Steel Corp.....18-19
Robbins & Myers, Inc.....22-23
Rollway Bearing Co., Inc..... 54

SKF Industries, Inc..... 31
Soss Mfg. Co..... 96
Stewart-Warner Corp., Alemite Div. 45

Texaco Instruments Incorporated, Metals & Controls Division.....90-91
Timken Roller Bearing Co., Steel & Tube Div..... 7
Tomkins-Johnson Co..... 14
Torrington Co. 40

Uniform Tubes, Inc..... 103
Union Carbide Plastics Co., Div., Union Carbide Corp..... 21
U. S. Electrical Motors, Inc..... 39
Universal Electric Co..... 27

V. & E. Mfg. Co..... 104
Valcor Engineering Corp..... 102

Waldes Kohinoor, Inc., Truarc Div. 47
Weckesser Co. 102
Winsmith, Inc. 46
Worthington Corp. .....2nd Cover

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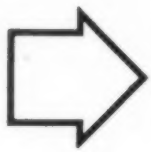

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2	22	42	62	82	102	122	142	162	182	202	222	242	262	282	302	317	332	347	362	377
3	23	43	63	83	103	123	143	163	183	203	223	243	263	283	303	318	333	348	363	378
4	24	44	64	84	104	124	144	164	184	204	224	244	264	284	304	319	334	349	364	379
5	25	45	65	85	105	125	145	165	185	205	225	245	265	285	305	320	335	350	365	380
6	26	46	66	86	106	126	146	166	186	206	226	246	266	286	306	321	336	351	366	381
7	27	47	67	87	107	127	147	167	187	207	227	247	267	287	307	322	337	352	367	382
8	28	48	68	88	108	128	148	168	188	208	228	248	268	288	308	323	338	353	368	383
9	29	49	69	89	109	129	149	169	189	209	229	249	269	289	309	324	339	354	369	384
10	30	50	70	90	110	130	150	170	190	210	230	250	270	290	310	325	340	355	370	385
11	31	51	71	91	111	131	151	171	191	211	231	251	271	291	311	326	341	356	371	386
12	32	52	72	92	112	132	152	172	192	212	232	252	272	292	312	327	342	357	372	387
13	33	53	73	93	113	133	153	173	193	213	233	253	273	293	313	328	343	358	373	388
14	34	54	74	94	114	134	154	174	194	214	234	254	274	294	314	329	344	359	374	389
15	35	55	75	95	115	135	155	175	195	215	235	255	275	295	315	330	345	360	375	390
16	36	56	76	96	116	136	156	176	196	216	236	256	276	296						
17	37	57	77	97	117	137	157	177	197	217	237	257	277	297						
18	38	58	78	98	118	138	158	178	198	218	238	258	278	298						
19	39	59	79	99	119	139	159	179	199	219	239	259	279	299						
20	40	60	80	100	120	140	160	180	200	220	240	260	280	300						

REPRINTS

593	594	595	596	597	598	599	600	601	602	603	604	
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304—Miniature Bellows Couplings
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326—Power-shift Transmission

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300—Linear Actuator
309—Time Switch
306—Rotary Solenoid
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318—Predetermining Counters
319—Thermocouple Material
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323—Dc Relay
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311—High-pressure Microfilter
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368—Transfer Films, 4 pp, Ampto Inc
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354—Cast Irons, 6 pp, Hamilton Foundry Inc
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365—Post Type Brakes, 2 pp, Hart Reduction Pulley Co

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361—Lock Washers, 12 pp, Shakeproof Div, Illinois Tool Works

MOTORS, ENGINES AND CONTROLS

350—Rotary Pumps, 16 pp, Roper Hydraulics Inc
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ELECTRICAL, ELECTRONIC COMPONENTS

352—Wire Wound Resistors, 20 pp, Daven Co
355—Solenoid Valves, 16 pp, Valcor Engineering Corp
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350—Rotary Pumps, 16 pp, Roper Hydraulics Inc
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1	21	41	61	81	101	121	141	161	181	201	221	241	261	281	301	316	331	346	361	376
2	22	42	62	82	102	122	142	162	182	202	222	242	262	282	302	317	332	347	362	377
3	23	43	63	83	103	123	143	163	183	203	223	243	263	283	303	318	333	348	363	378
4	24	44	64	84	104	124	144	164	184	204	224	244	264	284	304	319	334	349	364	379
5	25	45	65	85	105	125	145	165	185	205	225	245	265	285	305	320	335	350	365	380
6	26	46	66	86	106	126	146	166	186	206	226	246	266	286	306	321	336	351	366	381
7	27	47	67	87	107	127	147	167	187	207	227	247	267	287	307	322	337	352	367	382
8	28	48	68	88	108	128	148	168	188	208	228	248	268	288	308	323	338	353	368	383
9	29	49	69	89	109	129	149	169	189	209	229	249	269	289	309	324	339	354	369	384
10	30	50	70	90	110	130	150	170	190	210	230	250	270	290	310	325	340	355	370	385
11	31	51	71	91	111	131	151	171	191	211	231	251	271	291	311	326	341	356	371	386
12	32	52	72	92	112	132	152	172	192	212	232	252	272	292	312	327	342	357	372	387
13	33	53	73	93	113	133	153	173	193	213	233	253	273	293	313	328	343	358	373	388
14	34	54	74	94	114	134	154	174	194	214	234	254	274	294	314	329	344	359	374	389
15	35	55	75	95	115	135	155	175	195	215	235	255	275	295	315	330	345	360	375	390
16	36	56	76	96	116	136	156	176	196	216	236	256	276	296						
17	37	57	77	97	117	137	157	177	197	217	237	257	277	297						
18	38	58	78	98	118	138	158	178	198	218	238	258	278	298						
19	39	59	79	99	119	139	159	179	199	219	239	259	279	299						
20	40	60	80	100	120	140	160	180	200	220	240	260	280	300						

REPRINTS

593	594	595	596	597	598	599	600	601	602	603	604
605	606	607	608	609	610	611	612	613	614	615	616

*MULTIPLE PRODUCT ADS

Key No.	Specific Product

(please print or type) *If this is change of address, check box* ☐

Name..... Title.....

Street.....

City..... Zone..... State.....

Company..... Major Product Manufactured.....

1	21	41	61	81	101	121	141	161	181	201	221	241	261	281	301	316	331	346	361	376
2	22	42	62	82	102	122	142	162	182	202	222	242	262	282	302	317	332	347	362	377
3	23	43	63	83	103	123	143	163	183	203	223	243	263	283	303	318	333	348	363	378
4	24	44	64	84	104	124	144	164	184	204	224	244	264	284	304	319	334	349	364	379
5	25	45	65	85	105	125	145	165	185	205	225	245	265	285	305	320	335	350	365	380
6	26	46	66	86	106	126	146	166	186	206	226	246	266	286	306	321	336	351	366	381
7	27	47	67	87	107	127	147	167	187	207	227	247	267	287	307	322	337	352	367	382
8	28	48	68	88	108	128	148	168	188	208	228	248	268	288	308	323	338	353	368	383
9	29	49	69	89	109	129	149	169	189	209	229	249	269	289	309	324	339	354	369	384
10	30	50	70	90	110	130	150	170	190	210	230	250	270	290	310	325	340	355	370	385
11	31	51	71	91	111	131	151	171	191	211	231	251	271	291	311	326	341	356	371	386
12	32	52	72	92	112	132	152	172	192	212	232	252	272	292	312	327	342	357	372	387
13	33	53	73	93	113	133	153	173	193	213	233	253	273	293	313	328	343	358	373	388
14	34	54	74	94	114	134	154	174	194	214	234	254	274	294	314	329	344	359	374	389
15	35	55	75	95	115	135	155	175	195	215	235	255	275	295	315	330	345	360	375	390
16	36	56	76	96	116	136	156	176	196	216	236	256	276	296						
17	37	57	77	97	117	137	157	177	197	217	237	257	277	297						
18	38	58	78	98	118	138	158	178	198	218	238	258	278	298						
19	39	59	79	99	119	139	159	179	199	219	239	259	279	299						
20	40	60	80	100	120	140	160	180	200	220	240	260	280	300						

REPRINTS

593	594	595	596	597	598	599	600	601	602	603	604
605	606	607	608	609	610	611	612	613	614	615	616

*MULTIPLE PRODUCT ADS

Key No.	Specific Product

INDEX OF PRODUCTS ADVERTISED IN THIS ISSUE

After reading the advertisements classified below . . . MORE DETAILED INFORMATION about these products can be obtained by using the attached READER SERVICE CARD.

A

Adhesives 96
Air Motors (see Motors, Air)
Axles 96

B

Balls 91
Bearings
  Ball 31, 40, 52, 91
  Needle 40
  Roller 31, 38, 40, 54
Brass 86–87
Brazing
  Alloys 26

C

Castings 34–35, 105
Castings, Precision Investment 30
Clad Metals 90–91
Clips 102
Closures 43
Clutches
  Hydraulic 107
Coatings 28
Compressors ..... 2nd Cover
Controls
  Mechanical 56
Cords 100
Counters 107
Couplings
  Hydraulic 93
  Mechanical 100
Cylinders
  Hydraulic 14
  Pneumatic 14

D

Deep Drawing 32
Die Castings 48
Drafting
  Machines 104
Drives
  Right-Angle 100
  Variable Speed 39

E

Engineering Services
  (see also Production Services) 86–87

F

Fastening Methods 18–19, 29, 96
Film, Plastic 10
Fittings, Hose, Pipe & Tube 85
Floats 101
Flux 26

G

Gaskets 2
Gear Motors (see also Motor Reducers) 36
Gears 84, 89, 100

H

Hinges 96

I

Instruments
  Mechanical 94, 98

J

Joints
  Swing & Swivel 13
  Universal 95

L

Lamps, Indicator 92
Locks 29
Lubricating Equipment 11, 45

M

Metal Forming 32
Moldings
  Plastic (see Plastic Parts)
  Powdered Metal (see Powdered Metal Parts)
Motor Reducers (see also Gear Motors) 36, 49
Motor Starters 98
Motors, A-C
  Fractional ..... 4th Cover, 22–23, 27
  Integral ..... 4th Cover
  Sub-Fractional 22–23, 36
Motors, Air 41, 88
Motors, D-C
  Fractional ..... 4th Cover, 27
  Integral ..... 4th Cover
  Sub-Fractional 36

N

Nuts 29

P

Painting Equipment 86
Plastic Parts 28, 44
Plastics 21, 53
Plastics Laminated to Metal 53
Powdered Metal Parts 86–87
Production Services
  (see also Engineering Services) 86–87
Pumps
  Liquid 107

R

Reproduction Equipment 104
Retaining Rings 47
Revolving Joints (see Joints, Swing & Swivel)
Rod Ends 52

S

Seals ..... 3rd Cover, 78
Silicone Fluids 42
Silicones 42
Silver Alloys 26
Speed Increasers & Reducers 46, 49, 80
Spinning 32
Steel
  Alloy 7, 18–19
  Stainless 51
Switches 105

T

Thermostats 50
Torque Converters (see Couplings)
Tube Fabricating 5
Tubes 5
Tubing
  Plastic 98
  Seamless 5, 18–19 103

V

Valves
  Air 104
  Hydraulic 104
  Solenoid 102
Vibration Mountings 33

W

Wear Materials 37
Welding
  Nuts 18–19
Wiring Devices 100

Issue of July 10, 1961
PRODUCT ENGINEERING
Card Expires September 11, 1961

FIRST CLASS
PERMIT No. 64
NEW YORK, N. Y.

BUSINESS REPLY MAIL
No Postage Stamp Necessary If Mailed in the United States

Postage Will Be Paid By Reader Service Department

Inquiries Services Department
PRODUCT ENGINEERING
P.O. Box 601
Ridgefield, Connecticut

2

Issue of July 10, 1961
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P.O. Box 601
Ridgefield, Connecticut

1

What synthetic sealing materials should I use—and when

Environmental conditions generally dictate the type of synthetic rubber for a specific oil sealing application.

Where temperature, shaft speed, runout, eccentricity, and lubricant type are "normal", standard Buna N synthetic rubber compounds are satisfactory. If, however, the application is "dry running", a compound must be selected that will operate satisfactorily with a very small amount of lubricant. If the application involves excessive abrasion, highly "loaded" compound stocks should be provided. At temperatures over 250° F polyacrylics or silicone compounds are indicated; if high temperature is accompanied by a solvent base or additive lubricant, polyacrylics are definitely preferred.

Thus many variables govern successful oil sealing. The chart below gives more data; for complete information from the world's foremost oil seal laboratories, call your National Seal engineer. He's in the Yellow Pages, under Oil Seals or O-Rings.

SYNTHETIC RUBBER COMPOUNDS | **RECOMMENDED APPLICATIONS**

Comp. No.	Base Polymer	Min/Max Operating Temperature	Life Index	Price Index	Automatic Transmissions	Pinions	Axle Seals	Engine Seals	Misc. Applications
B-63	Buna N	—40°F/225°F	100	100				Excellent for small gas engines.	Excellent for small non-spring loaded seals.
B-86	Buna N	—30°F/225°F	100	100		Satisfactory for medium temperature applications.	Truck and automotive rear axles. General use.	Satisfactory as general purpose material where temperature permits.	General purpose Buna N applications.
B-94	Buna N	—60°F/250°F	100	100					Excellent against aromatics and some military aircraft oils, fuels.
B-95	Buna N	—30°F/225°F	100	100					Good dry running compounds for applications requiring high durometer stock.
C-6	Buna N	—30°F/225°F	100	100			Excellent for semi-rough axles. Has good wear qualities.		Good for pressure seals due to high durometer and clean trimming.
L-28	Acrylon BA-12	—30°F/300°F	400	125	Good for temperature range indicated.	Satisfactory in single lip construction.	Sealed bearing high temperature applications.	Satisfactory for automotive use. High temperatures.	Satisfactory for high temperature general applications. Can be used with EP or GL-4 oils.
L-34	Hycar PA-21	0°F/300°F	400	115	Good for temperature range indicated.	Dual lip limited contact for high temperatures.	Sealed bearing high temperature applications.	Satisfactory for automotive use. High temperatures.	Satisfactory for high temperature general single or dual lips. Ok with EP or GL-4 oils.
S-48	Silicone*	—80°F/400°F	1500	150	Excellent high and low temperature life.	Silicone Compounds Not Recommended With EP Lubricants at high temperatures.		Excellent for general engine use. Suggested for premium gasoline and Diesel engines.	Excellent wide range material. Avoid use in EP and GL-4 oils.
S-49	Silicone*	—80°F/300°F	600	130	Good at high and low temperatures.			Very good for general engine use; premium gasoline and Diesel engines.	Very good wide range material. Avoid use in EP and GL-4 oils.

*Silicones require special stabilization for satisfactory use in aromatic oils at high temperatures.

NATIONAL SEAL
Division, Federal-Mogul-Bower Bearings, Inc.
GENERAL OFFICES: Redwood City, California
PLANTS: Van Wert, Ohio; Redwood City and Downey, California

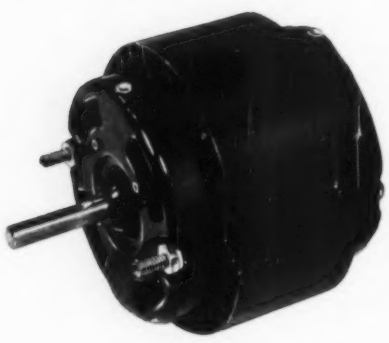
CIRCLE 202 ON READER SERVICE CARD

CONSTANT SPEED AND TORQUE OF **EMERSON ELECTRIC MOTORS**

is assured by balanced Die-Cast Rotors

The precision tolerances of the rotors in Emerson Electric Motors insure a uniform air gap for constant speed and torque. Noise and vibration are kept to a minimum by the symmetrical rotor design that provides a porous-free casting. The rotor is supported on each side to decrease the bearing load and give your application long, trouble-free operation.

EMERSON ELECTRIC MOTORS are custom engineered to suit your specific needs. Call us *today*—you'll like our way of doing business!



EMERSON ELECTRIC *of St. Louis • Since 1890*

DEPT. M-11, 8100 FLORISSANT • ST. LOUIS 36, MO. • CO 1-1800

CIRCLE 203 ON READER SERVICE CARD